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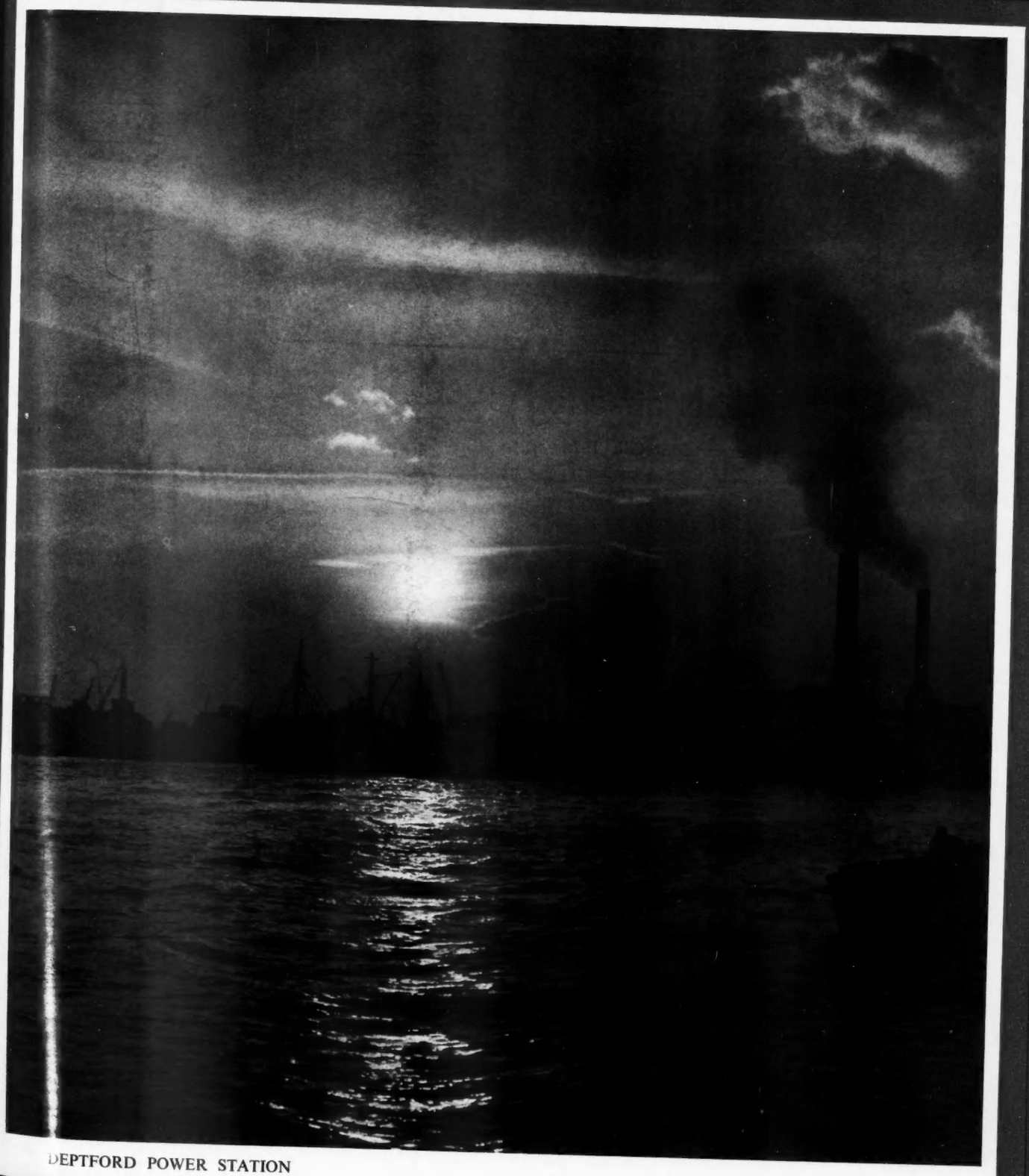

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THE BROWN BOVERI FLUID DYNAMICS AND COMBUSTION LABORATORY.

It will be readily understood that in developing their world-wide business in the production of steam and gas turbines, electrical machinery and apparatus in face of severe competition, Brown Boveri and Company, Limited, have had to make extensive use of experimental and research equipment at their works in Baden, Switzerland, in order to maintain and increase the efficiency of their products. Within recent years, several of the electrical departments have been provided with modern laboratories and in the course of a recent brief visit we have been able to see the latest addition to the firm's research and experiment facilities which takes the form of a new laboratory, specially designed, built and equipped for investigations in connection with the design of gas turbines, Velox boilers and other products which involve problems in fluid mechanics and combustion processes. Hitherto, such investigations have been carried out as and when required in different parts of the works, but as the design and construction of gas turbines is becoming of increasing importance and is likely to continue to grow, it was considered desirable to concentrate the necessary staff and equipment in a separate building to enable a rational programme of experiments to be carried out. In fact, a comprehensive research programme has been drawn up of sufficient magnitude to occupy the new laboratory for some years.

The decision to construct a new laboratory was probably influenced to some extent by the need to economise space, which is becoming scarce in the Baden works, so much so that some recent extensions to the shops have had to be made by building new storeys on top of the existing buildings. Space for the new laboratory was made by the demolition of a dwelling house in one corner of the works area, the resulting site being very roughly in the form of a right-angled triangle. The two sides containing the right angle are each about 39,700 m. in length

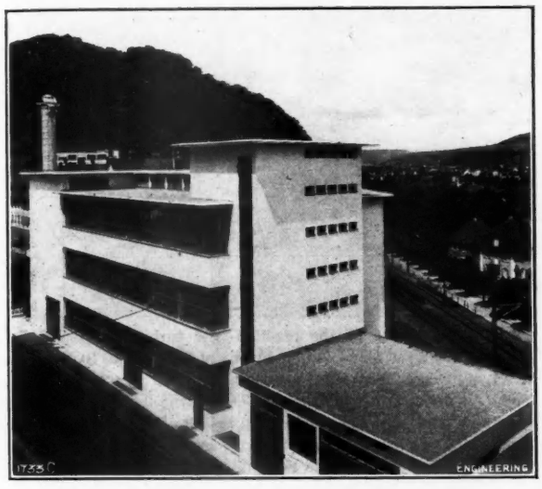

Fig. 1. Laboratory Building, Works Frontage.

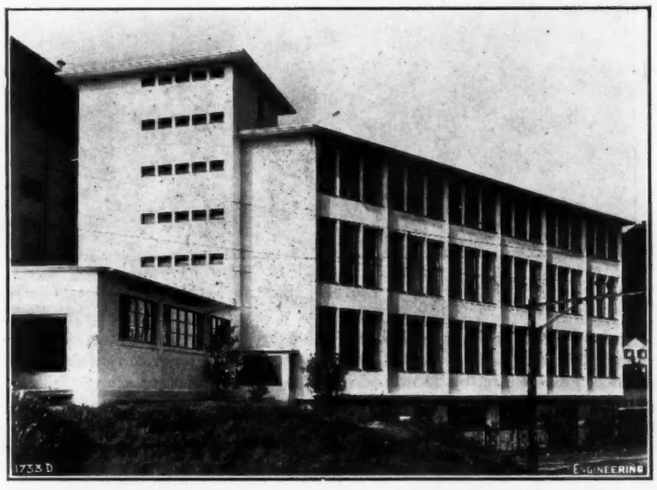

Fig. 2. Laboratory Building, Railway Frontage.

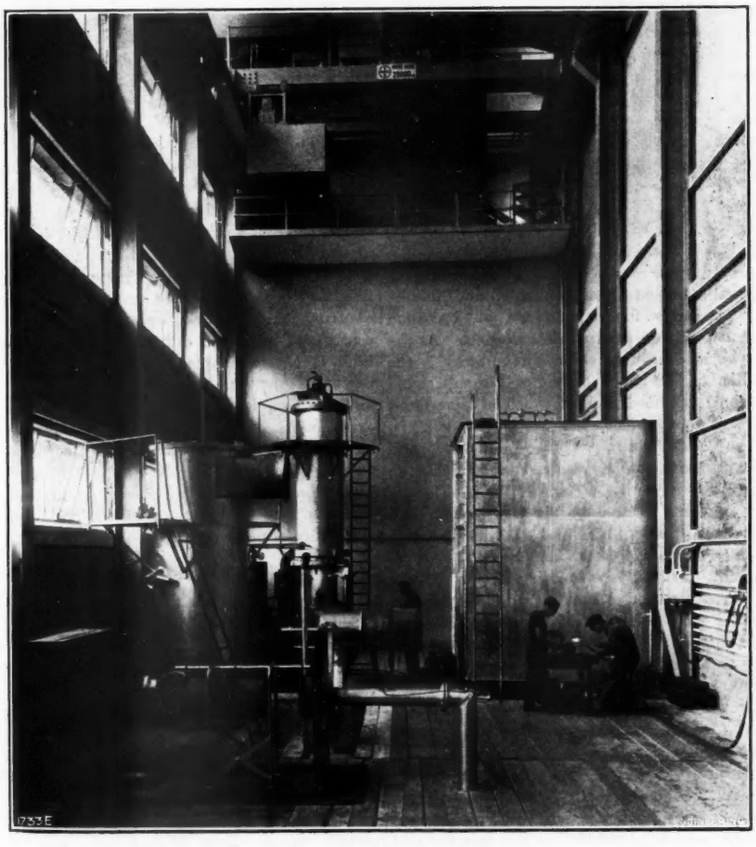

Fig. 3. Interior of Combustion Research Laboratory.

and the height of the building from the level of the lowest basement floor to the highest part of the roof is 27·25 m. The electrical laboratories and test equipment are still located in various parts of the works, but advantage has been taken of the space provided by the new laboratory to concentrate in it the transformers, switchgear, etc., required for distributing the current supply to the works test equipment. The latter is therefore now quite independent of the current supply to the productive parts of the works, so that production is not interfered with by electrical disturbances which may be set up by the testing equipment. Incidentally, the power required for testing purposes, which is taken from the public supply mains, now ranges from 20,000 to 25,000 kW.

New Laboratory Building.

Photographs showing the external appearance of the new laboratory building are reproduced in Figs. 1 and 2, on this page. As will be seen from Fig. 1, the site lies close to the track of the Swiss Federal Railways, the line shown connecting Zürich and Basle. Excavations for the foundations had to be taken down to a depth of 11·5 m. and to prevent possible subsidence, a mass-concrete retaining wall was constructed at the foot of the railway embankment. The other sides of the excavation were supported by sheet piling and raking struts. Three floors of reinforced concrete were constructed below ground level, the three upper floors of the fluid dynamics laboratory being of steel construction. For the distribution of electrical power to the works, as already explained, the lowest basement floor accommodates the cables and instrument transformers, and cells for the main transformers extend through both basement floors, the remainder of the second basement floor being occupied by switchgear. The third basement floor is used for the air, oil and water pipes and for certain auxiliary

FLUID DYNAMICS AND COMBUSTION RESEARCH LABORATORY.

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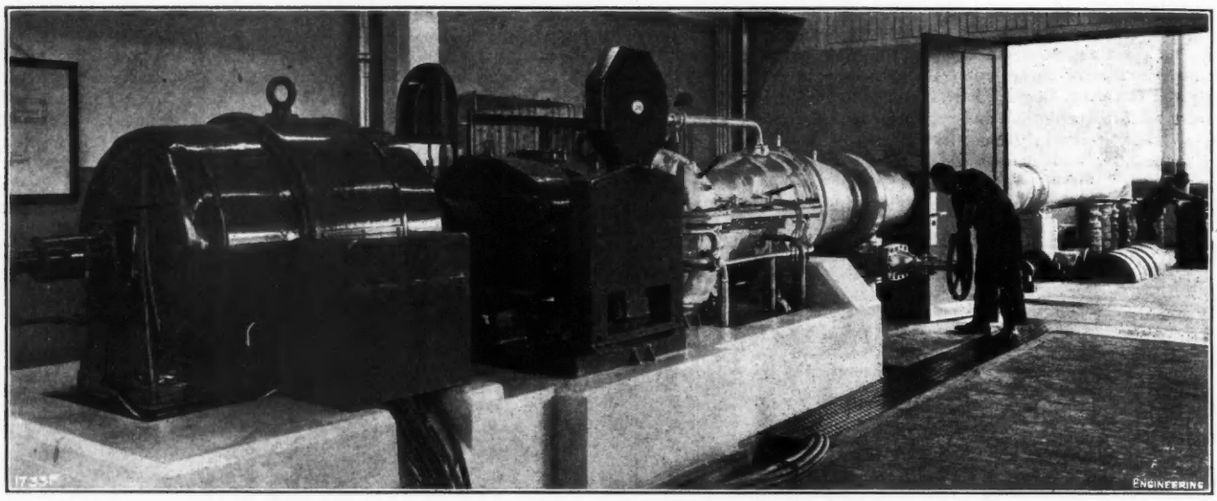

FIG. 4. DRIVING MOTOR AND AXIAL COMPRESSOR OF SUPERSONIC WIND TUNNEL.

machines required for the ground floor of the fluid-dynamics laboratory. The combustion laboratory has a floor area of 9 m. by 24 m. and its height is equal to that of three floors of the fluid dynamics laboratory. The height to the crane track is 12·3 m., this great height being necessary to enable experimental and prototype combustion chambers to be handled. It is also sufficient to accommodate hoppers for firing experiments with coal. The capacity of the crane, which serves the laboratory and a basement below it, is 20 tons. Fig. 3, page 609, shows the interior of the combustion laboratory.

The first and second floors of the fluid-dynamics laboratory are equipped with the apparatus required for investigations and the upper floor is at present used for offices. A total of 800 sq. m. is available for experimental work on the two floors and the clear height of 4·5 m. provided is sufficient for the erection of any existing or projected equipment.

PRINCIPAL ITEMS OF EQUIPMENT.

The space at our disposal does not permit us to describe in detail the electrical apparatus in the basement already briefly mentioned, but it is desirable to give some general particulars of the equipment of the laboratories. On the basement floor of the combustion laboratory pipes are provided to enable combustion chambers to be erected which extend down into the basement; the two air-inlet ducts for combustion air can be supplied with high-pressure air from the turbo-compressor house or with low-pressure air from two blowers with capacities of 10 and 8 cub. m. per second, respectively, installed on the same floor. The exhaust combustion gases pass through four connections, each 800 mm. in diameter, to a main pipe which runs in a duct outside the building to a stack 1,400 mm. in diameter, whence they escape to atmosphere. The upper end of the stack can be seen on the left in Fig. 1. The exhaust gases, it may be noted, are cooled to 300 deg. C., or less, by water sprays before being allowed to escape. At one end of the basement four liquid-fuel tanks are located in a fireproof room, which also contains the fuel pumps, preheaters and distributing valves.

At the same level, i.e., on the upper basement floor, is the lower section of the supersonic wind tunnel, including the air cooler, the fan for cooling the driving motor and the lubricating-oil pumps. The driving motor for the wind tunnel is supplied with direct current from an 800-kW converter set, and another converter set, of 150 kW, supplies the motors for small wind tunnels on the first floor of the fluid-dynamics laboratory. The greater part of the upper basement floor, however, is taken up by pipes of the air-supply and return system for the air turbines on the ground floor. Each of the test pits on this floor can be connected to either of the compressed-air lines and to the return line. As the air turbines are also connected to the turbo-compressor circuit, each turbine has a 300-kW air heater fitted at the inlet and an air cooler fitted in the return line to the turbo compressors. To enable the pressure in the system, and thus the Reynolds number, to be altered, a vacuum pump is connected to the supersonic wind-tunnel circuit and also to the system for the air turbines.

On the ground-floor level of the combustion laboratory are provided four covered pits, a stand for the production testing of fuel atomisers, experimental equipment for investigating fluid flow in combustion chambers, a chamber for carrying out actual combustion experiments, and finally, testing apparatus for experiments on corrosion and ash deposits on gas-turbine materials. At the same level in the fluid-dynamics laboratory is the upper half of the closed circuit of the supersonic wind tunnel, a photograph of which is reproduced in Fig. 4, above. The test section, it will be noted, is located in a separate measuring and computing room which also contains Schlieren apparatus for rendering air-flow visible. The air supply amounts to 6 cub. m. per second, the pressure ratio being 3·3, and the air velocity obtainable being 2,500 ft. per second. Air is supplied by an axial blower driven by a 750-kW direct-current motor through a dynamometer. The blower can be used for experiments on blading. For the time being, one impulse turbine and two reaction turbines, all driven by compressed air, have been erected on the test pits. All are fitted with Brown Boveri hydraulic brakes and Busch balances for torque measurements. The impulse turbine, illustrated in Fig. 5, opposite, is designed for a speed of 10,000 r.p.m. and a maximum output of 400 kW. Different shafts, with wheels having one or two rows of blading, can be fitted and various alterations and adjustments to the nozzles and blading can be made for experimental purposes. One of the reaction-type turbines has been constructed for an output of 700 kW at 10,000 r.p.m., and in this machine the central part of the cylinder can be changed to enable the height of the blades and the number of stages to be varied. The other reaction turbine is designed for the study of flow at the blade tips and in the clearances. Blades of various dimensions can be fitted and cascades with different axial pitches can be studied. The compressor house occupies a corner of this floor and contains three compressor sets two of which are driven by 750-kW variable-speed direct-current motors while the third, illustrated in Fig. 6, opposite, is driven by a 1,200-kW alternating-current motor. The direct current required is supplied by a 1,500-kW converter. The three compressor sets can be run in parallel, the air intake then being 10 cub. m. per second and the pressure ratio 4; the two smaller sets can be operated in series with an air intake of 2·3 cub. m. per second and a pressure ratio of 16.

The first floor of the fluid-dynamics laboratory is equipped with slide rails on the floor, instead of pits, and is provided with small wind tunnels for experiments on models and for investigations on centrifugal impellers, diffusers, etc. A water-flow tank is also available and we understand is to be supplemented by another tank. There is, however, ample space available for development experiments. Offices and a conference room extend along one wall on this floor and in a corner a room has been set aside for the optical inspection of blade profiles. As previously mentioned, the whole of the second floor of the fluid-dynamics laboratory is used for offices.

DEMONSTRATIONS.

During the brief visit mentioned at the outset of this article, demonstrations were arranged in the laboratories, and in the adjacent boiler house, in order to give visitors an idea of the class of work upon which the laboratories are normally engaged. One such demonstration was concerned with the vibration of turbine blades. It is well known that dangerous vibrations may be set up in blades subjected to a periodically varying flow if a state of resonance exists. Blades in cascade, however, may commence to vibrate in a perfectly steady air flow above a certain speed. This phenomenon was demonstrated in the supersonic wind tunnel, illustrated

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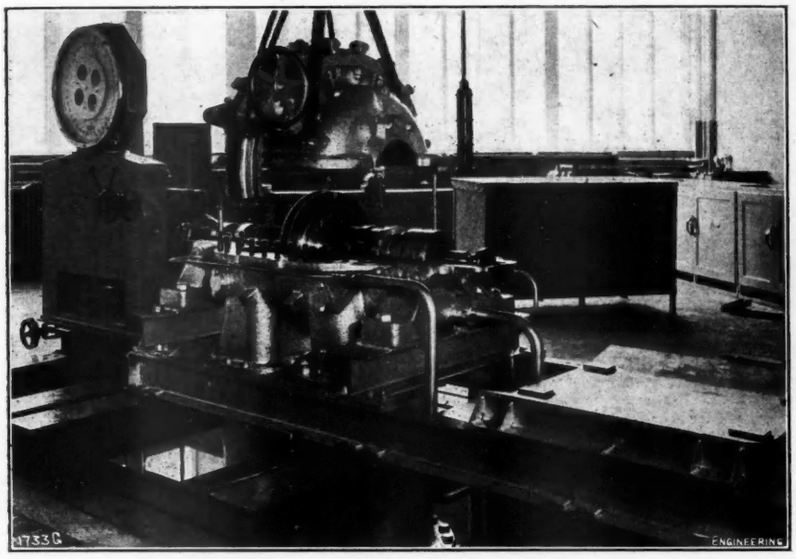


FIG. 5. EXPERIMENTAL COMPRESSED-AIR IMPULSE TURBINE.

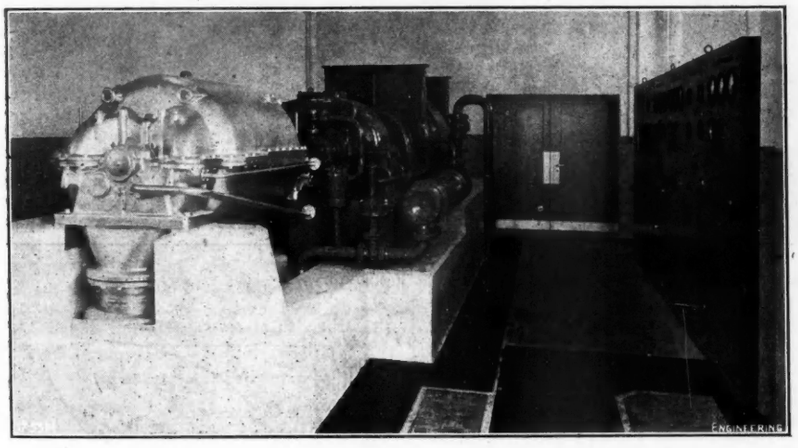


FIG. 6. COMPRESSOR SET DRIVEN BY 1,200-KW MOTOR.

in Fig. 4, the blades being mounted horizontally with their free ends near a window. Illumination by a stroboscopic lamp enabled the vibrations to be seen easily and effectively. Several wind-tunnel experiments were arranged to show the effects of flow separation and the means adopted to reduce it. The cases demonstrated were a turbine blade, a square-cornered tube of rectangular cross-section, and a rib in a turbine casing; in the particular case of the latter it was shown that the loss was greater at low speed than at high speed. The water channel was also employed to demonstrate the effect of separation in water flow. Two cylinders were fitted opposite each other in the walls of the channel with their axes vertical and with about half the cylindrical surface of each cylinder in air and half in water. When the cylinders were stationary, water flowing between them broke away and formed eddies downstream, but when the cylinders were rotated so that the wetted surfaces moved in the direction of flow the eddies died out and the flow became steady. The water flow was rendered easily visible by dusting the surface with aluminium powder.

One of the demonstrations in the combustion laboratory concerned burners for the combustion of liquid fuels. In the firm's gas turbines and Velox boilers the practice is to use only one nozzle per combustion chamber, because if two or more are employed and some are cut in and out to deal with changes of load there is a risk of clogging. In order to obtain sufficient control in a single injector each is provided with two concentric nozzles fitting one into the other to form a concentric double nozzle. When a certain load is exceeded injection is changed over automatically from the smaller to the larger nozzle, and vice versa. A sectional working model was shown to illustrate the action of the nozzle, and the behaviour of an actual burner was demonstrated with water. Fig. 7, on this page, shows a test of this kind in progress.

The air supply is introduced into combustion chambers with a swirling motion which produces a powerful back-swirl in the centre of the combustion space. This has been found to stabilise the flow and ensure satisfactory combustion throughout the whole range. The flow configuration was effectively demonstrated by means of a transparent model of a combustion chamber; tufts of wool attached to wires stretched across the

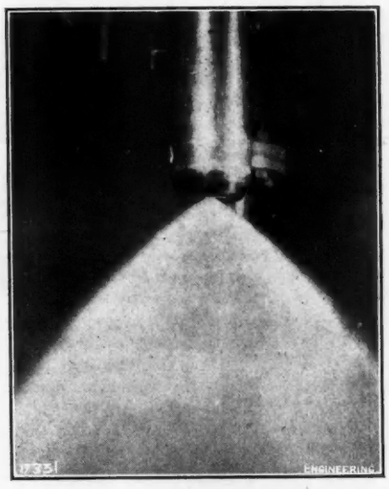


FIG. 7. WATER TEST OF BURNER FOR COMBUSTION CHAMBER.

chamber clearly indicated the general direction of the air flow. The casing in which this apparatus is enclosed is visible on the right in Fig. 3, on page 609. On the left of the same illustration can be seen two combustion chambers being prepared for testing and in front of them are two gas and oil burners for experiments on open flames. One of the demonstrations illustrated the combustion of methane which, as is well known, is practically identical in composition with natural gas. Owing to the limited ignition properties of this gas it is difficult to design a burner for a wide range of control, but with the burner demonstrated, as a result of appropriate co-ordination of the gas and air admissions, a stable flame was obtained with an excess-air volume ranging from 1·6 to 10.

The demonstrations in the boiler house were mainly concerned with problems arising from corrosion and ash deposits which occur in the combustion chambers and on the blading of gas turbines when certain heavy residual oils are employed. One type of test equipment available enables samples of heat-resisting steels to be exposed continuously under the same conditions as exist in turbines and examined for corrosion and deposits at suitable intervals. An obvious method of avoiding difficulties in gas turbines from fuels with high ash contents is to separate the ash from the fuel before it enters the turbine, and an experimental gas-producer installation was being employed for this purpose in one of the demonstrations, we understand with satisfactory results. Deposits which do occur on the blades must, however, be removed every few hundred hours in order to maintain efficiency, and it is desirable to be able to do this without shutting down the set. For this purpose, a pyrotechnic water injector was demonstrated. By exploding a small charge a spray of water is injected on to the blading and the brief thermal shock thereby produced is sufficient in most cases to dislodge the deposit. The Velox boiler installed in this boiler house supplies all the steam required for the works but is also used for long-term tests on various fuels that clients may wish to employ. Quite recently, satisfactory tests have been completed with low-temperature tar as fuel.

BEZNAU GAS-TURBINE POWER STATION.

An interesting and important application of the gas turbine is illustrated by the stand-by power

BEZNAU GAS-TURBINE POWER STATION.

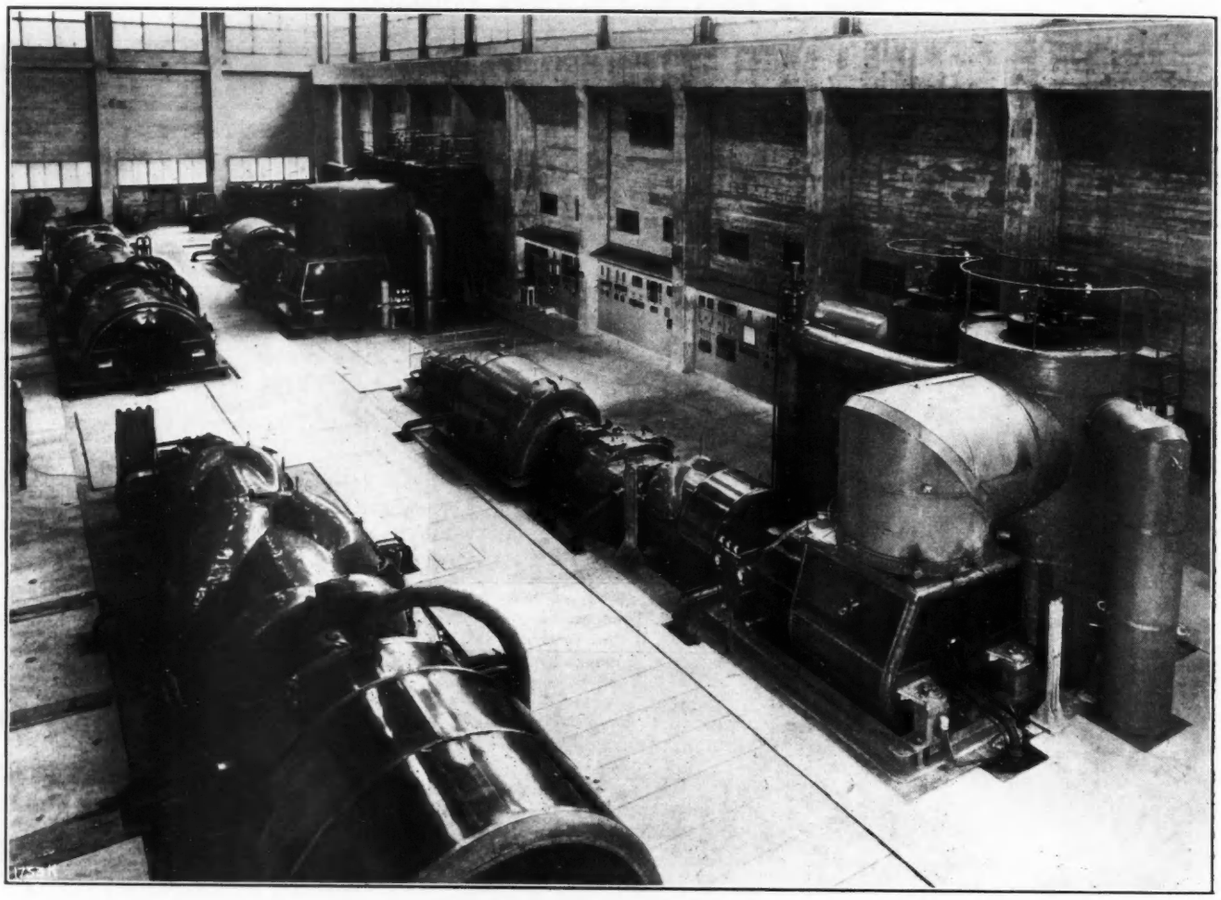


FIG. 8. INTERIOR OF MACHINE ROOM; 13,000-KW SET IN FOREGROUND.

Fig. 9. CYCLE DIAGRAM OF GAS-TURBINE SETS IN BEZNAU POWER STATION.

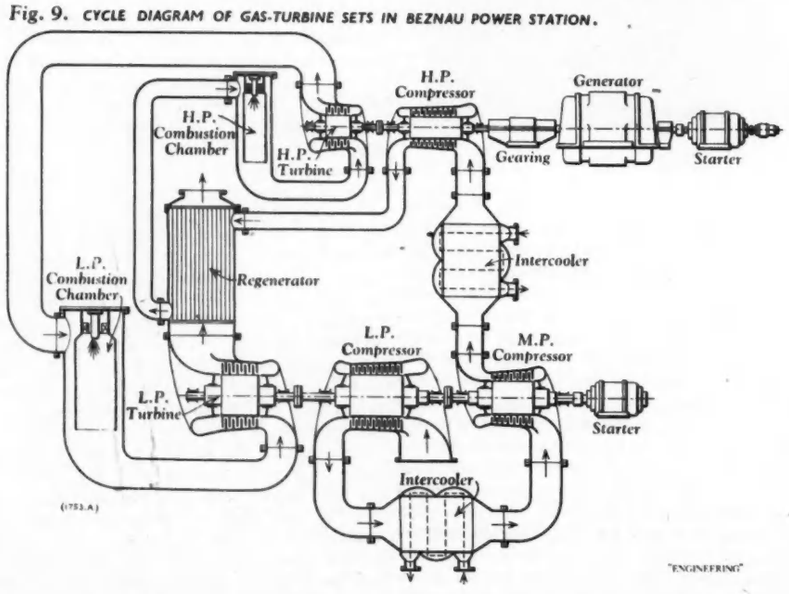
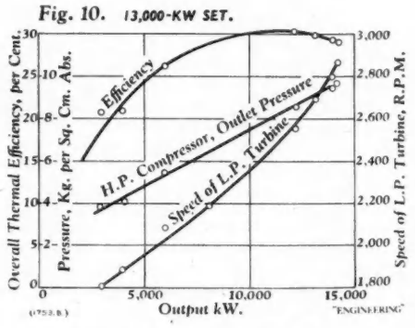


Fig. 10. 13,000-KW SET.



station of the Nordostschweizerische Kraftwerke A.G., at Beznau, near Baden, which the guests were able to see during their visit, and is understood to be the largest in the world. The power company decided to erect this station in 1946 and ordered two gas-turbine units, one for 13,000 kW and one for 27,000 kW, from the Brown Boveri Company, in June of that year. The smaller set was put into operation in January, 1948, and the larger set was started up a year later. The duty of this station, which is one of several water-power and thermal stations operated by the power company, is to supply power during the winter when, as sometimes happens after a dry summer, the water reserves are inadequate; it also enables power requirements to be maintained in the spring time in the event of the melting of the snow being delayed. In Switzerland, as in some other countries, the construction of new power stations has not been able to keep pace with the increasing demand for electrical power and for this reason the Beznau plant is used for about two hours each morning in the summer season to carry the peak load due to cooking. To meet these unusual conditions, the station is required to run throughout the year for different periods, ranging from 24 hours to two hours daily. Both machines were originally designed for a gas-inlet temperature of 600 deg. C., but after having operated for 6,000 hours at this temperature the smaller set was modified for an inlet temperature of

650 deg. C., and has since been running at this higher temperature for over 2,000 hours without trouble. In view of this satisfactory experience, the larger set has been modified this summer to operate at the higher inlet temperature. Using heavy fuel oil, the thermal efficiency of the whole installation is now 30 per cent. at the full load of 40,000-kW, the air and water temperature being 5 deg. C., which is the average figure for Beznau during the winter. Up till the end of August last, the 13,000-kW set had run for a total of 8,189 hours and delivered 78,394,000 kWh of energy, the corresponding figures for the 27,000-kW set being 5,543 hours and 102,724,000 kWh.

As will be seen from the diagram, Fig. 9, opposite, the turbines operate on the open cycle. The regenerators indicated in Fig. 9 are housed in a separate building which extends for the full length of the machine room the interior of which is illustrated in Fig. 8. In this illustration, the high-pressure and low-pressure sections of the 13,000-kW set are seen in the foreground, with the 27,000-kW set behind them. The two combustion chambers for the 13,000-kW set will be seen on the right and on the shaft nearest to them are the high-pressure turbine and compressor, the three-phase generator and the starting motor. The low-pressure turbine and compressor, the intermediate-pressure compressor and another starting motor are mounted on the left-hand shaft in Fig. 8. The graph, Fig. 10, shows how some of the characteristic data for the 13,000-kW set vary with the load.

In conclusion, it may be mentioned that the greater part of the thermal equipment manufactured by the firm of Brown Boveri, Limited, is produced for export and the majority of the guests invited to inspect the new laboratories were consequently from overseas. In the course of a fairly strenuous day they were able to see not only something of the experimental methods employed in the design and development of gas turbines but could see the machines in practically all stages of construction passing through the shops and finally saw them in operation under service conditions in the Beznau power station. Their experiences will probably help them to appreciate what has to be done to build up and maintain a reputation in connection with this comparatively modern form of prime mover similar to that which has been achieved by the firm with the older methods of power production.

40TH ANNIVERSARY OF THE SUPERMARINE AVIATION WORKS.—The Supermarine Division of Vickers-Armstrongs Ltd., Hursley Park, Winchester, have recently celebrated their 40th anniversary. In October, 1913, the name Supermarine was registered as a telegraphic address by Mr. Noel Pemberton Billing when he set out to build "boats that will fly, and not just aeroplanes with floats." In 1916, when Mr. Pemberton Billing sold out his interest, the company became known as the Supermarine Aviation Works, Ltd. In the same year, Mr. R. J. Mitchell joined the staff. Known principally as designer of the famous Supermarine Schneider Trophy racers and of the Spitfire fighter aeroplane, he was also responsible for the Southampton flying boats and their successors that did excellent service with Coastal Command from 1925 until the late 'thirties. In 1928, the Supermarine Aviation Works was acquired by Vickers (Aviation) Ltd., and ten years later both companies were taken over by Vickers-Armstrongs Ltd. The first Spitfire aircraft flew in March, 1936, and a year later Mitchell died. He was succeeded by Mr. J. Smith, who was responsible for the remarkable development of the Spitfire aircraft; in 1945, the top speed of the Mark 22 Spitfire was 450 m.p.h., just over a 100 m.p.h. faster than the 1936 prototype, and the rate of climb had increased from 2,500 ft. to 6,800 ft. per minute. The first jet fighter built by Supermarine flew in July, 1946, and, known as the Attacker, was adopted by the Royal Navy. A series of swept-back single-seat fighter prototypes led to the development of the Swift fighter aeroplane which is expected to enter service with the Royal Air Force this year. On September 25, the Swift, piloted by Mr. M. J. Lithgow, set up a world air speed record of 737·3 m.p.h. at Castel Idris, Libya. Shortly afterwards, however, this record was surpassed by a Douglas F4D Skyray, flying at 753·4 m.p.h.

LITERATURE.

Advanced Mathematics in Physics and Engineering.

By PROFESSOR A. BRONWELL. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 36, U.S.A. [Price 6·0 dols.]; and McGraw-Hill Publishing Company, Limited, 95, Farringdon-street, London, E.C.4. [Price 51s.]

THE importance of mathematics for students of the mechanical and physical sciences arises from the fact that it provides useful techniques for exploring several of the fields of research which have been opened up by recent advances in these sciences. In his book, Professor Bronwell demonstrates this and, at the same time, places the right emphasis on the need for a clear understanding of the fundamental ideas of the subject. Accordingly, the first three chapters deal with the mathematical foundations of infinite series, complex numbers, and Fourier series and integrals before the study is extended, in the next two chapters, to the consideration of ordinary differential equations, and the series solution of differential equations, including the Bessel, Legendre, and associated Legendre equations. Chapter 6, on partial differentiation, completes the essential preliminaries.

Applications to a wide range of problems in dynamics are introduced in Chapters 7 and 8, first to mechanical vibrations and electrical oscillations in systems with lumped elements, and then to systems with distributed elements. In the following chapter valuable guidance is given to a basically different, and highly important, approach to the formulation of dynamical problems, under the heading of "Lagrange's Equations." At this stage of the work, some readers may find it convenient to pass on to the solution of the wave equation, in Chapter 11, and subsequently return to the intervening discussion of vectors as a point of departure for the study of flow and field problems given in Chapters 12 to 14. These topics include the theory of heat transmission, the dynamics of both compressible and incompressible fluids, and the electromagnetic theory, and the formulation of them directs attention to the significance of Euler's equations, the equations of continuity and of state, and Maxwell's equations.

The treatment of functions of a complex variable, in Chapter 15, with its separate sections on Cauchy's theorems, methods of contour integration, and conformal transformation, leads by easy steps to a chapter on complex roots of polynomials. The growing importance of this subject is clearly indicated by applications to the problem of stability in the case of aircraft, servomechanisms, and electrical networks. Here the author presents, in 20 pages, an instructive account of the stability criteria of Routh-Hurwitz and Nyquist. Laplace transformations is another subject of special interest in physics and in certain branches of engineering, for reasons which are clearly stated in the concluding chapter of the work. The contents of a book of this kind must always be in the nature of a compromise, but the condensation or omission of certain topics is made good by the generous supply of references to standard works on particular domains, and of useful exercises, with the answers placed at the end of the text.

Tables for Rocket and Comet Orbits: United States National Bureau of Standards. Applied Mathematics Series, No. 20.

By SAMUEL HERRICK. U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 1.75 dols.]

THE possibility of navigating rockets in space has directed serious attention, for the first time, to rectilinear motion in the problem of two bodies, and to the consequent need for adequate tables of the functions required to deal with the principal problems of orbit computation. This book of tables of sin E and 1 — cos E with argument E — sin E, together with the parallel tables of hyperbolic functions, is therefore to be welcomed because it renders possible the determination of position and velocity from the time in the case of rectilinear orbits. It is written by an expert computer, as may be seen by inspection of the tables. First, they have been obtained by direct interpolation, without the aid of series expansions or successive approximations; the inverse process, that of finding the time from position or velocity, is solved by inverse interpolation. Secondly, they work even near perihelion for nearly parabolic orbits. On this point, Mr. Herrick's critical test is not the nearly parabolic orbit, but the rectilinear one; for both kinds of orbits the device that makes the tables usable is the subdivision of them into "ranges," the first of which, for $n \geqslant 5$, may be used repeatedly like a table of logarithms or a table of powers, and it yields at least eight significant figures, no matter how close the moving body may approach to perihelion, perigee, or coincidence. Thus these tables provide a treatment that is more general than the nearly parabolic one; they will apply to the parabola, whereas the latter will not apply to the rectilinear orbit.

The first 19 pages of the book are devoted to descriptive matter on the origin of the functions tabulated, which include the first and modified second differences, and on applications of them with particular reference to the process of interpolation, inverse as well as direct. Of like interest in this introductory part of the work is the explanation of how the tables may be utilised for eccentricities of all values, including zero. The method of solving the nearly rectilinear problem is based upon that developed by the late Dr. L. J. Comrie for the solution of Kepler's equation when the eccentricity is not too near unity. An advantage of the process and the accompanying tables is that they together obviate, for all eccentricities, the difficulty met with in the standard form of Kepler's equation, which arises from the lack of sufficient figures in any tables of sin E to give requisite accuracy in the expression for the mean anomaly when the eccentric anomaly is nearly zero and the eccentricity of the orbit is nearly unity. The reader will find in these pages a number of applications of the use of the tables to the ellipse, hyperbola, and parabola.

The series of seven tables, which occupy the 100 pages that follow the introduction, have been prepared with great care and skill. Since the final manuscript was prepared on an IBM card-controlled typewriter, before being reproduced by the offset process, special attention was paid to the testing of the tabulated figures. The method employed for the purpose, which is described in some detail, is unexceptionable, and so is the arrangement of the tables, as is to be expected in work associated with the National Bureau of Standards.

Kinematics of Mechanisms.

By DR. ING. N. ROSENAUER and PROFESSOR A. H. WILLIS. Associated General Publications Pty., Limited, 26, Hunter-street, Sydney, New South Wales, Australia. [Price 90s. (Aust.).]

THIS book is notable for two reasons: it is the first important book on an engineering subject to be published in Australia, and it is the first work to be published in English to serve as an introduction to the major developments which have taken place in *Getriebelehre* (the study of mechanisms) since the time of Reuleaux. If it leads to a better appreciation of the importance of this field of engineering theory in the English speaking engineering schools, there may be some chance of regaining the lead in the design of mechanisms which Britain held in the time of Watt.

The detailed perusal of this work, however, leaves a feeling of disappointment at opportunities lost. Essentially this is a German text-book published in English out of its context, and no attempt has been

made to supply the background necessary for its proper understanding. Indeed, despite their preface, the authors do not appear to have decided what was to be the object of the book, which, in fact, is largely an exposition of the graphical methods of dealing with the problems of velocities and accelerations of mechanisms and their centrodes, to which Dr. Rosenauer has made many contributions, together with an introduction to Beyer's approach to the synthesis of mechanism. There is also a good chapter on redundancy in linkages. The reader familiar with the German literature will find nothing new to him. It is a pity that there are no references to the work of Roberts and Kemp and others in this country, or to that of Klein and, more recently, of Hrones and Svoboda in America.

The reader unfamiliar with the kinematic school from which this work springs needs to realise, however, that it is a school which is sharply divided in its approach to kinematic problems; evidence of this is supplied in the present work by the authors' brusque dismissal of analytical methods, and the failure to mention Rauh's work on synthesis. It is a pity that the book does not begin with a short account of the various problems facing the designer of mechanisms, with an indication of the several approaches to them which are known, in order both to put the remainder of the work in its proper perspective and also to make the reader realise the importance of the very dry book-work of the Euler-Savary equation and the constructions developed from it. Books on engineering should not be desiccated.

Had the authors paid more attention to the analytical approach, they could scarcely have failed to notice that two of the mechanisms (the centrodes of which they exceptionally obtain analytically) have practical applications, since the mechanism with parabolic centrodes must generate Joukowski profiles, and the crossed parallelogram mechanism, the centrodes of which are hyperbolae, must generate Piercy profiles. Furthermore, they would have noted that it is theoretically possible to design a four-bar chain to generate a curve passing through any six points, and they would have mentioned the work of Svoboda and others. They would also have discussed the straightness of the approximate straight-line mechanisms.

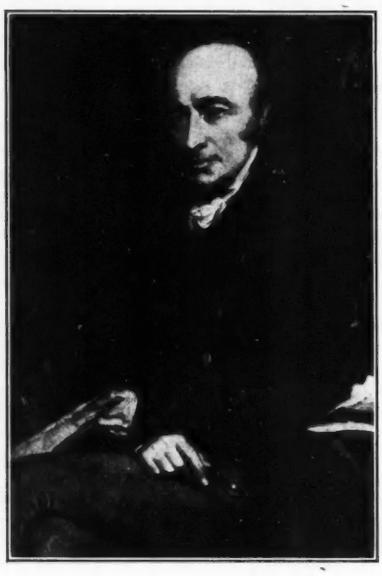
A more serious criticism of the book, however, is in the question of nomenclature. Anyone who has tried to translate German kinematic literature into English will be well aware of the difficulties involved, due to the lack of an accepted English terminology. The authors have not only missed a great opportunity of developing such a terminology, but have made the situation worse by using "movable" and "immovable" centrodes in place of the accepted "moving" and "fixed" centrodes. A chapter headed "Relative Motion of Three Planes" suggests at once spacial mechanisms, whereas, in fact, the problems discussed concern the relative motion of two bodies in a plane. Nevertheless, the authors must be congratulated on having produced a book that will prove stimulating to many readers. It is to be hoped that they will add a further volume to provide both a general introduction to *Getriebelehre* and a detailed discussion of the astonishing versatility of the four-bar chain.

British Electricity.—The British Electricity Authority have published a well-illustrated booklet with the title "Giant Power" which summarises the progress made since vesting day—April 1, 1948. In so doing, it gives a number of useful statistical data regarding sales, prices and trading results. The expansion of the power stations which has taken place during the same period is also described and stress is rightly laid on the increasing efficiency of generation. Some details are given regarding the 275-kV grid and the cross-Channel link, while such matters as research, welfare, negotiating machinery, safety, health and education and training have not been forgotten. The price of the booklet is 1*s.* and copies can be obtained from the B.E.A., Winsley-street, London, W.1.

WILLIAM HYDE WOLLASTON, 1766-1828.

By Graham H. Friese-Greene.

The chemist and natural philosopher, William Hyde Wollaston, was born in East Dereham, Norfolk, on August 6, 1766, and died in London on December 22, 1828. In his sixty-two years his accomplishments and discoveries covered more branches of the sciences than those of any of his famous contemporaries, but it is only now that the value of much of his life's work can be adequately assessed. Wollaston was the second son of the Rev. Francis John Wollaston of Chislehurst, Kent; a Fellow of the Royal Society, a clergyman of some standing, and well known as an astronomer.* His grandfather was likewise a Fellow of the Royal Society, and his great-grandfather was the celebrated author of *The Religion of Nature Delineated*. Young William Hyde certainly inherited an aptitude for



learning and showed early intuition and understanding of the natural laws. He was educated at Charterhouse and Caius College, Cambridge, and like his father, astronomy appeared to be his favourite pursuit. He did not graduate in Arts, however, but studied medicine and took his degree (M.D.) in 1793. He was elected a Fellow of the Royal Society the same year; became its secretary in 1806; interim president in 1820; and received the Society's Royal Medal in 1828 at the end of a life singularly devoted to science and the Society he loved.

Commencing his practice with little success as a physician at Bury St. Edmunds, Suffolk, he soon came to London but proved too sensitive for medical tasks. Then, finding it necessary to increase his income, he turned his thoughts to analytical chemistry, and by his discoveries, particularly in the platinum metals, he made a fortune by 1808. Most of his original work was directly with chemistry, but he diverged his interests and studies from one science to another and was able to bring together much accumulated and organised knowledge with advantage to science and industry as a whole. His capacity to contrive pieces of apparatus for basic experiments and his grasp of essentials appeared at times to be the touch of a genius. His laboratory was small. Many discoveries were made by persistent and systematic examination on a small scale, even microscopic. The identities of rare minerals were established with only a few grains. It was a source of pride to him that by a sprinkling of means he could produce great results. He was austere, unimpassioned and accepted his successes with a monk-like calmness.

It was in chemistry and optics that he gained the greatest recognition, but a close study of his published works indicates that he was responsible for, or germinated, important advances in mineralogy, crystallography, mechanics, acoustics, astronomy, physiology, pathology and botany, and as time has since told, his discoveries influenced the birth and assisted the growth of a new art and science, photography. Like many scientists of his day, Wollaston upheld the arts and crafts, and in his search for truth and beauty the influence of fine art is apparent, particularly in his sense of values and his philosophy. But he was a business man, too; he had a keen appreciation of the ultimate economic value of his researches, realised the technological requirements of industry, and sat on innumerable Government commissions.

Chemistry.

In chemistry he specialised in the platinum metals. His introduction of the platinum crucible in 1800, followed by successes in reducing platinum from the raw state into ingots, via powder metallurgy, opened up vast fields of research for men of science; and with industrial applications, new developments in the machine and chemical world leapt ahead. Meanwhile, his discovery of palladium and rhodium in crude platinum, announced in 1803* with an account of the properties and characteristics of the new metals, established his fame as a scientist at a comparatively early age, and posterity honours this wave of discoveries as being one of the important epochs in the history of metals.

His identification in 1809 of a titanium compound (he thought it was metallic titanium) in slag at the bottom of an iron furnace brings into focus, nearly 150 years later, a light-weight non-corrosive structural metal that maintains high-tensile strength at moderately high temperatures. The metal was actually recognised for the first time by Wollaston's contemporary, Gregor. During 1809, Wollaston proved the elementary character of columbium (niobium) now used in austenitic stainless steel to diminish susceptibility to "weld decay," and in making heat resisting steels for jet engines. He also discovered the identity of tantalum used as an acid-resisting metal in chemical industry, and published an analysis of meteoric iron, and showed that potash exists in sea-water.

In 1810, he discovered crystine, a substance very prominent in biochemical research. Wollaston was the first to ascertain the nature of the then so-called cystic oxides, and also chalkstones that sometimes appear in the joints of gouty patients. He was the first to distinguish the nature of the triple phosphates, and his first chemical paper on urinary calculi was an important advance in knowledge at that time. In the assumption of hydrogen as the radix or unity, Wollaston founded an improved scale of chemical equivalents which, according to contemporary thought on this complex subject, is a valuable addition to the atomic theory.

Optics.

To recapitulate the reaction of Wollaston's own contemporaries to his work in optics, it can be said that it was chiefly his verification of the Huygenian law of double refraction, his investigation of the refractive and dispersive powers of bodies on which the perfection of the achromatic telescope depends, and the ingenious and elegant method practised by him for perfecting the adjust-

* *Fasciculus Astronomicus* by Francis John Wollaston was published in 1800.

* It was to mark the triple jubilee of Wollaston's announcement of his discovery that the Institution of Metallurgists held their Platinum Metals Exhibition from October 19 to 24 at Grosvenor House, Park Lane, London, W.1.

ment of the triple achromatic object glass, that gave him the highest claim to eminence in this science. In 1802, Wollaston was the first to observe the dark lines in the solar spectrum, an important discovery leading to separate branches of physical inquiry. Of the seven lines he observed, he regarded the five most prominent as natural boundaries or dividing lines of the pure simple colours of the prismatic spectrum, which he supposed to have four primary divisions. The dark lines in the spectrum were later independently observed with more refined means and in greater detail by Fraunhofer.

Wollaston's reflecting goniometer, described in 1809 as an instrument for measuring angles, was a most valuable present to mineralogists, and also by its introduction crystallography benefited in being able to exhibit higher degrees of definition. Wollaston made a very simple apparatus for ascertaining the power of various bodies to refract light. He provided microscopists with the Wollaston doublet, and applied concave-convex lenses to assist the oculist.

Photography.

Wollaston was one of the band of scientific men in the late Eighteenth and early Nineteenth Centuries that contributed to make chemistry an exact science and to develop its technological aspects, without which photography in its commercial form could not have developed. Also, the debt owed by photographic science to Wollaston's pioneer work in optics is best illustrated by the entry in Fox Talbot's diary under the date August 28, 1828: "Camera Obscura for Wednesday." It was Wollaston who produced the *camera lucida*. Later that year Wollaston died. It seemed that it was destined that the torch was to pass to a fresh hand, that of Talbot's, to direct and illumine a new science in which chemistry and optics have merged triumphantly. Fox Talbot recorded in his "Pencil of Nature" (1844) that he used a "camera obscura" as early as 1823, but with indifferent success. Fox Talbot's all important experiments that produced his photogenic process, negative to positive, took place much later, between 1834 and 1839.

Perhaps the most direct contributions Wollaston has made to the art and science of photography as we know it to-day, are his discoveries of the metals platinum and palladium. Hand sensitized platinum paper, and more recently palladium, are undoubtedly the finest contact printing mediums for pictorial work. Although colour possibilities are restricted to black and sepia, the great advantage over other printing mediums is its permanence, possibly to the extent of thousands of years. In platinum printing, potassium chloroplatinite (K_2PtCl_4) is used in solution; in palladium printing, either potassium chloropalladite (K_2PdCl_4) or sodium chloropalladite (Na_2PdCl_4) may be used.*

Other Sciences.

Wollaston's invention of the cryophorus is an example of bringing together remote branches of knowledge in the sciences. The cryophorus was described in 1813 in a paper "On a method of freezing at a distance." Wollaston made important contributions to the early experimental and theoretical work on electricity. In 1818 he communicated to a philosophical magazine a "Description of an Elementary Galvanic Battery." In 1821, after Oersted (1777-1851) had shown that a magnetic needle is deflected by an electric current, he attempted to transform that deflection into a continuous rotation, and also to obtain the reciprocal effect of a current rotating round a magnet. He failed in both respects, but Faraday succeeded shortly afterwards. Wollaston became a member of the Geological Society in 1812, and is famous for the medal awarded annually for promoting researches concerning the mineral structure of the earth. Wollastonite is a rock-forming mineral named after the scientist in recognition of his work in the service of this branch of science. Wollaston lived at 18, Cecil-street, Strand, from 1797-1801, 14, Buckingham-street, Fitzroy-square, from 1801-1825, and at 1, Dorset-street, Manchester-square, from 1825-1828. A memorial plaque was unveiled on July 4, 1934, at his residence in Buckingham-street, by Sir Frederick Gowland Hopkins, then president of the Royal Society.

* See *American Photography*. "Hand sensitized Platinum Paper," by Paul L. Anderson. October, 1937, and July, 1938.

THE DUTY TO FENCE DANGEROUS MACHINERY.

By C. F. Mayson, A.M.I.E.E.

When considering the fencing of dangerous machinery to comply with the safety provisions of the Factories Act, 1937, and of the Regulations made thereunder, it is necessary to determine the scope of the protection to be provided. This is particularly so where the guarding of the dangerous parts of a specific type of machine is dealt with by regulation. Within the past ten years, the Courts have come to some important decisions, and have expressed very definite opinions, about the extent of protection required and, in so doing, have clarified a number of points which, to lawyers at least, have previously been in doubt. These case-law decisions have a definite bearing upon the purely practical issues involved in the design of machinery guards, and engineers who are concerned in these matters, whether as occupiers of factories or as designers and manufacturers of machines, may obtain some assistance from a reasoned exposition of the law as it now stands.

The Obligation to Fence.

It will save later explanation if the obligation to fence, as provided by Sections 12, 13 and 14 of the Factories Act, 1937, is considered first. These Sections deal, respectively, with prime movers, transmission machinery and other machinery. In each case, the words "shall be securely fenced" are used, and these words make the primary obligation an absolute one; there is no room for discretion. But there are exceptions, so that electric generators, motors and rotary converters, and their flywheels (Section 12), all transmission machinery (Section 13), and dangerous parts of other machines (Section 14) need not be fenced provided that they are "in such a position or of such construction as to be as safe to every person employed or working on the premises" as though they were securely fenced.

It is Section 14 with which engineers are mainly concerned. Whether a part is a "dangerous part" is a question of fact. This has already been referred to in these columns,* and all that need be said here is that parts of machinery are dangerous if danger may reasonably be anticipated from their use without protection. If they are dangerous, they must be protected, and if they cannot be securely fenced, or made safe by position or construction, the use of the machine is virtually prohibited. The proviso to Section 14 (1), that an automatic device may be used instead of a fixed guard, gives an exception, not an alternative method. However, by Section 14 (2), the Secretary of State (now the Minister of Labour and National Service) may make regulations as to the use of safety devices designed to overcome the difficulty of complying with the Section. So far, no such regulations have been made. Instead, Special Regulations have been made under powers given by Section 60, and these are directly related to Section 14, and must be read in conjunction with it. They are the Building, Jute, Horizontal Milling Machines, and Woodworking Machinery Regulations.

Regulation 85 of the Building (Safety, Health and Welfare) Regulations, 1948, extends the absolute obligations of Sections 12, 13 and 14 to building works, with certain additional and particular requirements provided by Regulation 86. The Jute (Safety, Health and Welfare) Regulations, 1948, specify with great particularity in the First Schedule how a round dozen of machines used in the processing of jute are to be safeguarded, and Regulation 27 states specifically that these provisions are to be "without prejudice" to Section 14 (1). On the other hand, the Horizontal Milling Machines Regulations, 1928, in naming a number of exemptions, provide that they "shall not prejudice the application of Section 10 of the Factory and Workshop Act, 1901, in regard to fencing of such machinery" (that Section being now Section 14 of the 1937 Act), but do not do so in regard to the Regulations themselves. The Court of Appeal considered this in *Benn* v. *Kamm & Co. Ltd.*,* and decided that Regulation 3, which deals exhaustively with the fencing of cutters, applies only to the cutters as such and does not oust the requirements of Section 14 as to the protection of other parts of milling machines.

Since the case of *Benn* v. *Kamm* in 1952, it can be stated as a general rule that none of the Special Regulations made by virtue of Section 60 supersedes the obligations of the Act, except when they deal with the same danger or aspect of danger; but it is clear that they may modify the absolute obligations of Section 14, where applicable. Although the Woodworking Machinery Regulations, 1922 (as modified by the Woodworking (Amendment of Scope) Special Regulations, 1945) make no mention of being without prejudice to the provisions of Section 14, the Court of Appeal held in *Miller* v. *William Boothman & Sons, Ltd.*† that Regulation 10 modified the Section, and Mr. Justice Hilbery in *Harrison* v. *Metropolitan Plywood Co.*‡ followed that decision in respect of Regulation 17. This means that these Regulations do not replace Section 14, unless, in any particular case, their requirements are comprehensive enough to embrace the whole purpose of the Section.

Extent of the Obligation.

Having considered the obligation to fence, as laid down, it is now necessary to deal with the extent of that obligation. The question is, who is to be protected?; that is, who is to be kept in mind when designing a guard? A satisfactory reply cannot be given unless the answer to a second question is known: against precisely what danger is the protection needed? Is it to keep an employee away from dangerous moving parts, or is it to prevent the escape of something which might injure him? At first sight, the purpose of any sort of guarding would seem to be to keep employees away from a source of danger. The bars are not those of a prison, intended to confine, but are a fence to keep people away. On the other hand, a lion is confined in his cage in a zoo because it would be dangerous to let him escape, and he is fenced off from the spectators because it would be equally dangerous to let them into the cage. This may be so with, say, a machine tool. The operator who feeds the machine must be prevented from feeding himself into it; but if part of the tool is likely to break off, or spoil from cutting is likely to be thrown out, someone may be struck and injured by a flying piece of metal or other material.

Broadly speaking, fencing may be required (*a*) to keep individuals away from the dangerous parts of a machine. In this event, it may be necessary to bear in mind one person only, such as the operator

* See "Safety Provisions of the Factories Acts," by C. F. Mayson, Engineering, vol. 174, page 214 (1952).

* (1952) *Law Reports* (2 *King's Bench*), page 127.
† (1944) *Law Reports* (*King's Bench*), page 337.
‡ (1946) *Law Reports* (*King's Bench*), page 255.

of a machine tool, or all persons who, in the course of their duties, may accidentally come into contact with some moving part, such as a belt or gearing. Alternatively, the fencing may be required (*b*) to protect individuals from the consequences of the escape of a broken part or the throwing out of spoil. Here all persons likely to be in the vicinity must be considered. Although this is a fair summary of what may be required, it must be read in the light of the law as it is at present, for case-law decisions to date qualify these requirements to some extent.

The wording of Sections 12, 13 and 14 is such as to make it quite clear that the provisions of the Act itself are for the protection of "every person employed or working on the premises." In *Nicholls* v. *F. Austin (Leyton) Ltd.** the claim was for damages for injury caused by a piece of wood spoil which flew out from a type of circular saw known as a straight-line edger. The House of Lords decided that there could be no claim under Section 14, for the object of that Section is to protect employees and others from coming into contact with any dangerous part of a machine. By Section 14 (3), powers are given to make regulations "requiring the fencing of materials or articles which are dangerous while in motion in the machine," but, so far, no such regulations have been made; any duty to fence materials in motion was therefore excluded. Further, the machine in question was provided with the type of protection detailed in Regulation 10 of the Woodworking Regulations, which do not specify guarding to prevent spoil flying out from a machine. On these grounds the claim failed.

The position may be very different, however, where it is a part of the machine itself which flies out and causes injury. In *Hindle* v. *Birtwistle*† in 1896, a Divisional Court of Queen's Bench had to consider the case of injury to a weaver caused by a shuttle flying out of the shuttle-race of a loom, and held that provisions of the Factory and Workshop Acts of 1878 and 1891, analogous to those of Section 14 of the 1937 Act, applied in such an event. The Court ruled that the obligation to fence "all dangerous parts" was not confined to those parts which were dangerous in the ordinary course of careful working, but included parts which were likely to fly out with any degree of frequency. A similar result was obtained by a different process of reasoning in *Harrison* v. *Metropolitan Plywood Co.*, noted above. There, part of a cutter of a spindle moulding machine broke off and injured a worker at an adjacent machine. In holding that Regulation 17 of the Woodworking Regulations applied, Mr. Justice Hilbery pointed out that the Regulation required "the most efficient guard" to be fitted. The evidence showed that a ring guard, of a type designed to protect the operator only, had been fitted. But in "Safety Pamphlet No. 8,"‡ issued by the Home Office in 1928, there was illustrated a type of guard consisting of a wire-mesh screen which fitted round the vertical spindle. The use of such a guard would have complied with the Regulation, which the ring guard certainly did not. The injured person therefore succeeded in his claim.

In 1948, the House of Lords decided in *Carroll* v. *Andrew Barclay & Sons, Ltd.*,§ that the requirements of Section 13 were confined to protecting employees from coming into contact with transmission machinery, and did not oblige occupiers to erect an enclosure to prevent broken machinery flying out. In that case, an employee was injured by a broken balata belt which flew out from above the guarding and struck him; the guard provided was adequate to protect employees under normal conditions. The conditions in this case were not the same as in *Hindle* v. *Birtwistle*, where shuttles had a propensity to fly off the race; and the decision in the *Harrison* case was based on a breach of the Woodworking Regulations and not of Section 14. The House expressly reserved consideration of the question whether Section 14 really requires a machine to be so fenced as to protect employees from the ejection of broken parts.

In July of this year, the Court of Appeal expressly approved the decision in the *Harrison* case. This was in *Dickson* v. *Flack*,* where an employee, who was testing a vertical spindle moulding machine, was injured by a bolt which flew off the head-piece when it was revolving at high speed. It was held that the Shaw guard fitted to the machine, while effective to protect the operator from coming into contact with the cutters, was not the most efficient guard within Regulation 17 of the Woodworking Regulations, for it did not guard against the known danger of pieces flying out of the machine. But, because the Regulation did not specify the type of guard required, it did not deal exhaustively with the occupier's duty; hence the general duty under Section 14 still applied. The Court emphasised that, in the *Carroll* case, the House of Lords had left open the question of a machine which might have a propensity to throw off loose or broken parts. The danger of vertical spindle moulding machines throwing off cutters was a very real one, as was emphasised in a pamphlet issued by the Factory Department of the Ministry of Labour and National Service in 1947.† This was therefore a case where the duty to fence extended to protecting employees from the danger of parts flying out from a machine.

Referring back to the summary, it can be stated with absolute certainty that the obligation to fence extends to protecting all persons who, being lawfully on the premises, are likely to come into contact with a dangerous part of a machine; but it will suffice to have only the operator in mind in the case of those tools which do not have a propensity to throw off loose or broken parts. In this connection, it should be remembered that it is sufficient to comply with the requirements of the relevant Section or Regulations; although it may be advisable to follow the recommendations of the Factory Department in many cases, such action is by no means compulsory.

In dealing with part (*b*) of the above summary, one is not on such firm ground. Although it can be said with certainty, on the authority of the *Nicholls* case, that there is no necessity to guard against the ejection of spoil from a machine, the law is far from certain when it comes to considering the throwing out of broken parts. Both the *Harrison* case and *Dickson* v. *Flack* concerned breach of Regulation 17 of the Woodworking Regulations, and the decision in the latter case will be followed in other cases concerning that Regulation; but it would be unwise to infer that the same reasoning will be followed in cases dealing with different regulations. The House of Lords left the question open in the *Carroll* case, and, until that House has an opportunity of considering the matter more fully, the law will remain somewhat uncertain. There is no doubt, however, that, whatever the state of the law, it would be highly advisable to guard against the escape of loose or broken parts from machines which are likely to throw them out.

Exceptions to Absolute Duty to Fence.

It remains only to deal with Sections 15 and 16 of the Act, which are subsidiary to Sections 12, 13 and 14 (Section 17, which concerns the responsibility of manufacturers, is rather outside the scope of this article). The two Sections must be read together, for they provide what are, in effect, certain exceptions to the obligation to fence. Section 16 states that all fencing is to be "of substantial construction, and constantly maintained and kept in position while the parts required to be fenced or safeguarded are in motion or in use," except when "necessarily exposed" for examination, lubrication or adjustment. Section 15 deals with exceptions to the matters to be considered when determining whether machinery is safe by position or construction; these exceptions also concern the examination, adjustment and lubrication while in motion. The carrying out of work covered by the exceptions must be in accordance with the Operations at Unfenced Machinery Regulations, 1938 and 1946, which apply to both Sections. In this connection, there is an important decision of the Court of Appeal in *Nash* v. *High Duty Alloys, Ltd.*,* which affects both Sections and the Regulations. Firstly, Regulation 1 provides that Regulation 5 does not apply to tool-setters; nevertheless, tool-setters are within the class of machinery attendants covered by Regulation 2. Secondly, a machine is not "necessarily exposed" within Section 16 if, during an inspection or test, the machine is set in motion for an operation and the guard is left off, although the operation could just as easily be performed with the guard in position. Finally, there can be no compliance with these two Sections (or with the Regulations) unless the provisions of Sections 12, 13 or 14, as the case may be, have been observed.

It is hoped that this attempt to clarify the law relating to the obligation to fence machinery has succeeded in making the position reasonably understandable to engineers. The Sections of the Act which have been discussed are probably among the most important of all, and, certainly, they seem to attract a great deal of attention from the Courts. Much thought has been given to these Sections by lawyers, and endless ingenuity has been expended by engineers in endeavours to meet requirements; but, whatever the state of the law may be at any given moment (and it changes more rapidly than is sometimes realised), it behoves all engineers and users of machinery to provide the highest possible standard of protection against those dangers which are inseparable from the association of the human element with the machine.

New X-Ray Diffraction Equipment.—The new X-ray diffraction unit of Philips Electrical, Ltd., Shaftesbury-avenue, London, W.C.2, comprises a system of interchangeable "sealed-off" tubes with different anode materials and high transmission mica-beryllium windows. The need for a separate and continuously-operated vacuum system is thus avoided and the equipment is ready for use directly it is switched on. The high-tension generator employs a single thoriated tungsten filament valve, while the smoothed direct-current output is stabilised electronically to within 0·1 per cent. and is unaffected by frequency drift. Each working position on the camera table has an electro-magnetically operated shutter, and there are a number of interlocks to guard against failure and ensure correct operation.

Electricity Supply in New Zealand.—The report of Mr. W. S. Goosman, Minister in Charge of the State Hydro-Electric Department, New Zealand, discloses that the total output, in the North Island, during the year ended March 31, 1953, was 2,392 million kilowatt-hours, an increase of 2·4 per cent. over the figure for the previous year. In the South Island the corresponding output was 1,082 million kilowatt-hours, an increase of 4·9 per cent. These results were obtained in spite of a period of water shortage, an explanation being that more generating plant, including three sets at Maraetai, was brought into service. The possibility of constructing a geothermal station at Wairakei with a capacity of 20 MW is being surveyed, while several other hydro-electric projects are being actively pursued. Substantial extensions are also being made to the transmission network.

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* (1946) *Law Reports* (*Appeal Cases*), page 493.
† (1897) *Law Reports* (1 *Queen's Bench*), page 192.
‡ "Fencing and Other Safety Precautions for Woodworking Machinery."
§ (1948) *Law Reports* (*Appeal Cases*), page 477.

* (1953) *Weekly Law Reports*, page 571.
† "Safety Hints on the Use of Woodworking Machinery." Form 279, H.M. Stationery Office, page 14.

* (1947) *Law Reports* (*King's Bench*), page 377.

FACTORY BUILDINGS OF TUBULAR CONSTRUCTION.

FIG. 1. FACTORY FOR ROTAX, LTD., AT HEMEL HEMPSTEAD.

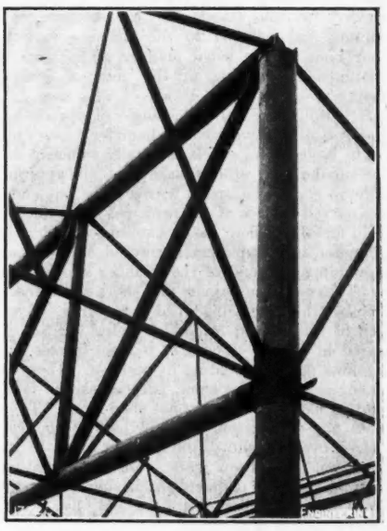

FIG. 3. JUNCTION OF LATTICE GIRDER WITH MAIN COLUMN.

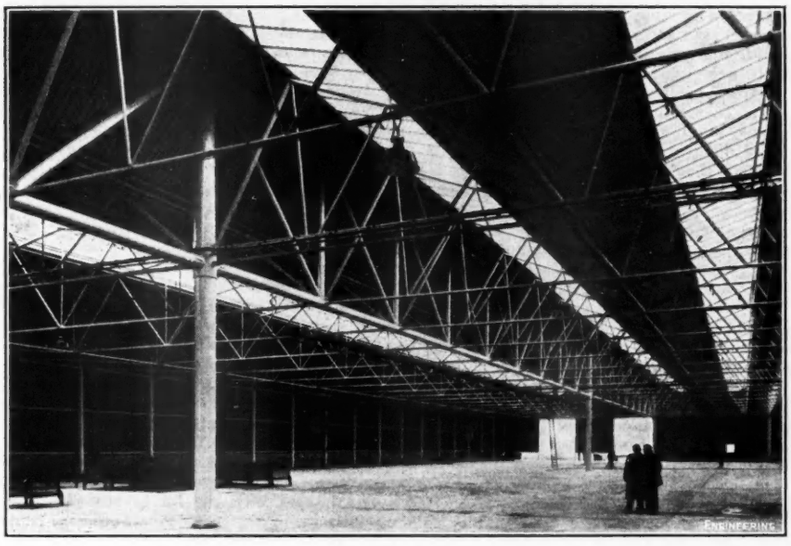

FIG. 2. KIRKBY FACTORY OF TUBEWRIGHTS, LTD.

TUBULAR-STEEL FRAMES FOR FACTORY BUILDINGS.

THE use of welded tubular-steel members for single-storey factory buildings results in a structure of pleasing appearance and a saving in the weight of steel used which may amount, it is claimed, to as much as 40 per cent. in comparison with a similar structure of conventional rolled-steel sections. This saving in weight leads to a direct saving in the cost of the steel amounting to between 10 and 20 per cent. and to secondary savings of considerable magnitude on foundations, handling and erection charges, and maintenance, to an extent which it is difficult to assess. This saving in material is achieved partly as a result of the large number of tube sizes available, both in outside diameter and wall thickness, which makes it possible to select just that member which is required with a minimum of wastage.

The possibilities of tubular-steel construction were recognised long ago—both the Forth Bridge and the Menai Straits railway bridge are early and outstanding examples of such construction—but its use for building frames has only become a practical and economic proposition with recent developments in welding techniques. Pioneers in this field have been Tubewrights, Limited, the constructional subsidiary company of Stewarts and Lloyds, Limited, Upper Brook-street, London, W.1, and this company have recently been responsible for two large factory buildings of this type. The buildings are one built for Rotax Limited, at Hemel Hempstead, Hertfordshire, and another built by Tubewrights, Limited, for their own use on the Kirkby Trading Estate, Liverpool. The interiors of these two buildings, which have floor areas of 165,000 and 140,000 sq. ft., respectively, are shown in Figs. 1 and 2, above. The buildings are of interest because, apart from their size, they are also the most recent structures of this kind to be erected in the United Kingdom. Similar, but smaller, structures have been built in considerable numbers and many have been exported, particularly to tropical countries where this high light-weight form of construction gives an impression of coolness. Tubular construction is not limited, however, to buildings: the 282-ft. boom of the world's largest walking dragline was built by the same company, and they are also fabricating standard roof trusses, bridges, crane jibs and gantries, transmission towers and a wide variety of other equipment in the same way.

Of the two factory buildings, that at Kirkby is the heavier. The main shop is 360 ft. square and 17 ft. high to the eaves, divided into six intermediate bays, 360 ft. long by 40 ft. wide, and two end bays 360 ft. by 60 ft. The spacing of the columns is 120 ft. by either 60 ft. or 40 ft., according to the width of the bay and each column consists of a single 16-in. diameter mild-steel tube. The roof trusses, at 13 ft. 4 in. centres, are carried on lattice girders of 120 ft. span. Over the 40-ft. wide bays the trusses are of the butterfly type, partly glazed on both slopes, while above the end bays of 60-ft. span they are flat-pitched and glazed only at the apex. The roof covering is an aluminium decking combined with insulation board and two layers of felt. It is recognised that this is an expensive method of roof construction, but it is estimated that the extra cost will be saved in the first five years by the reduced heating costs due to the smaller heat losses. The sides of the building are of an asbestos-protected metal sheeting above a brick surround.

All the steelwork for the structure was delivered to the site as tube and all the cutting and fabrication done there. Two mobile cranes were used for the erection of the structure, which, including all fabrication and final welding, was carried out in 4½ months. The factory is to be used by the company for the further production of tubular-steel structures and other similarly fabricated equipment, and it is intended that the maximum use shall be made of conveyor equipment suspended from the roof structure. For this reason, an allowance has been made for live loading on the trusses equivalent to 20 lb. per square foot of floor area, and for a point load of 2 ton at each panel point.

The factory at Hemel Hempstead is a somewhat lighter structure. To suit the various requirements of production, it has been planned on a module of 60 ft. by 40 ft. to give a main shop 460 ft. wide (seven spans of 60 ft. and one of 40 ft.) by 360 ft. long (nine bays of 40 ft.). The requirement of an even intensity of light at working level has been met by providing a monitor roof with the principal glazing on the sloping north flank but with some additional glazing in the smaller, vertical upstand on the south side. The 60-ft. trusses have been designed to carry ½-ton point loads at each of the four intermediate panel points to allow for services and other suspended loads, these being in addition to deadweight and all normal roof loadings. The final design showed that about 6 lb. of steel was used for each square foot of floor covered, as compared to 6½ lb. for the Kirkby factory. Comparable figures for a conventional steel design were estimated to be between 9 and 10 lb. per square foot. The components for the Hemel Hempstead factory,

however, were all prefabricated and then transported to the site ready for final erection.

As with welded structures generally, the baseplate of each column consists of a single plate welded—without cleats—to the bottom of the column and secured to the concrete footing by four bolts in the usual manner. The amount of cutting and shaping of the ends of individual members of frames depends on the sizes of the intersecting tubes and the angle of approach. In the case of relatively small diameter tubes running on to large principals, it is usually sufficient to cut the smaller tube either square or at the appropriate oblique angle, the space between the cut end and the curved surface of the principal being filled with weld metal. Where the two tubes are both of large diameter and simple cutting would be too wasteful in welding, the end of the member which requires to be shaped is cut square and short and fitted with a collar which is itself shaped as required. A variation of this shaped collar—receiving "cups," illustrated in Fig. 3—is used to register trusses on the columns prior to welding in position. These cups, of course, serve the same purpose as the familiar landing cleat in conventional steel-work. To complete the connection, the top half of the cup is welded over the end of the member after the structural weld has been made. On this question of shaping the ends of members, it should be realised that all the tubes are flame-cut by workmen experienced in pipe fitting.

Expansion joints are more easily made in tubular construction than in conventional steelwork. The free end of an expanding member is freely supported in a loose collar which permits temperature movements. This raises a problem which is, however, easily overcome. It is imperative to prevent internal corrosion of the tubes and, where the ends of tubes are not closed by the connections, they must be specially sealed.

Many of the advantages of tubes as a structural form arise from the uniform distribution of material about the centre line, giving equal sectional properties about all axes. To take full advantage of this property, it is desirable to locate all the members in the theoretical plane of the frame and to make the axes of all members nominally meeting at a point to intersect at that point. This is, of course, desirable in all structural frameworks, but it cannot always be realised in conventional steelwork, whereas with tubes it is readily achieved. Where many members meet at a point, it may be necessary to crimp the ends of some of the members, but this is easier than the joggling which is required for upsetting angle sections. An alternative device for arranging complex connections—but which has not yet been adopted in practice—is to locate the ends of all members on a sphere sufficiently large to avoid interference between the ends of several tubes. Such an arrangement would have the advantage that the ends of all members would be cut square, and the sphere itself would offer no difficulties for it could be welded from two hemi-spherical pressings. Another problem which had to be solved on the Kirkby factory involved the reinforcing of the column tube at a point where it was likely to be subjected to lateral thrusts, too large for the tube to sustain, from the lower booms of the main trusses. As is illustrated in Fig. 3, this difficulty was solved by fitting a collar around the column.

The appearance of lightness of this form of structure has already been referred to, but the tubular form has another advantage over the conventional rolled-steel sections namely, cleanliness. Unlike angle and joist sections, tubes do not offer the same ledges on which dust can settle. This "lightness" of the structure is possibly best appreciated when, standing at one end of a factory 360 ft. long, it is possible to look the length of the structure and see the glazing at the far end between the members of the many intervening frames.

The consulting engineer for the two factory buildings was Mr. T. Bedford, 41, New Bond-street London, W.1, and the tubular structures were fabricated and erected by Tubewrights, Limited. The general contractors were, for the Hemel Hempstead factory, J. Jarvis and Sons, Limited, 12, Buckingham Palace-gardens, London, S.W.1, and at Kirkby, Taylor Woodrow Construction, Limited, Southall, Middlesex.

FUEL AND PRODUCTIVITY.*

By Dr. A. Parker, C.B.E., F.Inst.F.

As you know, I am concerned with all fuels and products of fuels in the interests of the country as a whole.† It is my duty, and privilege, to endeavour to take a balanced view of the situation, and to look ahead so as to guide research and development work and their application in what seem to be the right directions in the broad national interest. What I shall try to do to-day, in the limited time available, is to give you a broad picture of the situation—as I see it—as an introduction to subsequent addresses during this session.

Fuel Utilisation and National Prosperity.—It is recognised that, in general, those countries with the greater consumptions of fuel and energy in relation to size of population have the higher industrial productivities, and, in consequence, the higher incomes and standards of living. This observation indicates the importance of supplies of energy to supplement man-power, if relatively high standards of living are to be maintained. For the world as a whole, the average consumption of all fuels and power is equivalent to rather less than 1½ tons of coal per person annually. In the United States, it is equivalent to roughly 8 tons, in this country to about 4½ tons, and in the backward countries to only a fraction of a ton per person per annum. The United States, with a population only one-fifteenth of that of the world, uses rather more than one-third of the total world production of fuel and energy. Deducting the fuel used for heating houses and other buildings to provide the warmth for personal comfort, the United States uses between two and three times as much fuel and power per inhabitant as we do for industrial productivity. There is no evidence that on the whole the efficiency of utilisation of fuel and power in industry is very different in the two countries. It is not surprising, therefore, that the United States is relatively so prosperous. We, in turn, are much more prosperous than most other countries; but other countries are certain to develop their own industries as their educational systems improve. In consequence, international competition in industry and commerce must steadily become more intense.

This problem of facing international competition is one of the major problems with which we are faced now and in the immediate future. We can only meet the situation by providing more power per individual to increase our industrial productivity, and thus to maintain and improve our competitive position in international markets. Without such improvement we cannot pay for the necessary imports of foods and raw materials to maintain a population so large as 50 millions on this small island. How is this improvement to be effected?

Fuel and Energy Resources.—Let us first take a broad view of fuel and energy resources. Of known resources of the fossil fuels, that is, coals, oils, natural gas, and peat, 97 per cent. is in the form of coals and lignites, 1 per cent. occurs as petroleum and oil in oil shale, 1 per cent. as natural gas, and 1 per cent. as peat. By known techniques, probably only one-third to one-half of the known coal resources could be economically brought to the surface. Even so, there is enough coal in the world as a whole to last for 2,000 years at present rates of production. The United States has nearly one-half of the known coal resources; that is, enough to meet her needs for 2,000 years at her present rate of production. The corresponding period for the U.S.S.R. is 1,500 years. We, however, have enough for only 200 or 250 years; and the position is not so good even as these figures indicate, because we have been drawing extensively on our coal resources for longer than any other nation, so that our better and more easily won seams of coal have been depleted or are being rapidly depleted. In consequence, the average cost of winning coal in this country is much greater than in the United States and in some other parts of the world. Further, the coal resources of this country have been more thoroughly surveyed than those of most other countries, so that we are less likely to discover additional resources of any magnitude.

World known resources of petroleum are sufficient for only 20 or 25 years at present rates of production. New resources are periodically discovered as a result of extensive prospecting by the oil companies, but with steadily increasing difficulty and cost; and the demand for oil increases every year. It may be that supplies of petroleum will become difficult within the next 50 years. There are, however, large reserves of oil in oil shale—larger than the known resources of petroleum. As petroleum becomes depleted, the recovery of oil from oil shale, which is now more expensive, is sure to be developed, so that the world may have ample supplies of natural oil for, say, 100 years. Again, however, we are badly placed in relation to other countries. We have virtually no natural petroleum, and our oil shale reserves could provide no more than three times our annual oil consumption. Similarly, our reserves of natural gas, even in coal measures, are relatively small; and our resources of peat are equivalent to no more than our coal production over about 20 years.

Fuel Efficiency.—Clearly, therefore, if we are to harness more power to increase productivity, we must use our fossil-fuel resources—almost entirely coal—with the maximum practicable and overall economic efficiency—and be well to the fore in developing other sources of energy such as water power, wind power, atomic energy, and the terrestrial heat energy within the depths of the earth. But here I must say something about fuel efficiency. Measurements of efficiency as ordinarily made by engineers and scientists are of value in comparing processes and equipment of different types and design to serve the same main purpose; but the results usually refer to only one or two stages in a whole complex sequence of events, from the production of the original source of energy to the final stage of utilising the heat or energy.

Let us consider, for example, the production and utilisation of gas and coke. This involves coal mining, coal preparation, handling, transport, carbonisation or gasification, collection, storage, and distribution of the products to the consumers, use of the product fuels to provide heat and power, and finally utilisation of the heat and power. Of all these stages, only the carbonisation and gasification processes, and the processes of utilisation, are ordinarily tested to give figures for efficiency as generally understood. Yet all stages require labour, power and equipment in the construction of which labour, materials, and fuel and power have to be employed. The generation, supply and utilisation of electricity from coal-fired stations involve a similar sequence of operations or processes.

Processes with the highest thermal or energy efficiency in this narrow technical sense are not always those with the highest overall efficiency, because the additional efficiency at any one stage may be obtained at a cost disproportionately high in other directions in labour, power, and materials. Perhaps the best guide to true overall efficiency or usefulness is the overall cost of the service to the consumer; though true overall cost is not always easily obtained with the complexities of hidden subsidies, tariffs, and other devices, which may for various reasons be necessary or desirable. Costs may also be affected appreciably by the efficiency or inefficiency of organisation, supervision, and labour. Still, on the whole, cost, taking all factors into account, is usually the best guide.

Fuel Savings.—Taking all these complex factors into account, so far as they can be assessed or guessed, my own estimate of the practicable economic saving of fuel that could be achieved in this country within the next 20 years, for the same productivity, is equivalent to between 15 and 20 million tons of coal a year. This does not include any appreciable saving in domestic heating, because it seems to me that more efficient domestic appliances will be used to obtain greater comfort and not to save fuel so long as the householder can afford to buy the fuel. This estimate of fuel saving—15 to 20 million tons—for the same productivity—is much lower than the estimates given previously by some other authorities. In my view, some of those earlier estimates have been economically unrealistic.

* Address delivered to the Fuel Luncheon Club, at the Connaught Rooms, London, on Tuesday, October 20, 1953. Abridged.

† Dr. Parker is Director of Fuel Research, Department of Scientific and Industrial Research.

The saving I have estimated, however, is substantial and must be attained; though it certainly cannot be achieved without much education and great determination on the part of all concerned. In any case, the fuel saved in this way should be used to provide more power to step up substantially our industrial productivity; and if we are to progress as we wish, even more power still will be required.

The Future.—I may have painted a picture that is a little depressing so far as this country is concerned; but it need not be depressing if we realise that the price of success is hard work on the part of everyone, vigilance and sound judgment, with avoidance of all unnecessary waste, whether of man-power or material. There are ample supplies of energy for the world as a whole—much more than the energy resources of known reserves of coal, great as these are. As the harnessing of some energy resources becomes more difficult and expensive, other resources will gradually take their place—first as marginal resources. We must strive to be in the lead in these developments.

In future we have to sell our skill; we cannot go on indefinitely exporting large amounts from our dwindling gold reserve in the form of coal. We must realise that a great change is occurring, and we must be fully prepared in every way. Two wars have caused great upheavals, but the fundamentals of economics remain the same. We can as a nation live only at the standard we earn. Last but not least, there is the human element. Human beings seem to become degraded by possessing too much power over others for too long. Excessive power corrupts, whether in the hands of dictators, governments, bureaucrats, employers, or employees. A healthy balance must be maintained. I leave you to decide for yourselves where the lack of balance now lies in the fields of fuel and power. If there is lack of balance, can it be put right by greater efforts in developing sources of power other than coal, to supplement what coal we can obtain? The oil industry has made one move in this direction by the installation during recent years of large refineries in this country. There are other directions.

FRENCH POWER RESOURCES AND THEIR UTILISATION.*

By J. COUTURE.

FRANCE has only meagre supplies of fuels. The production of petroleum amounts to only 2 per cent. of the consumption and imports rose to about 22 million tons of refined products in 1952. There is only one deposit of natural gas with an annual production of 1,000 million cubic feet. In 1952 the French coalfields produced 57·5 million tons and 18·5 million tons had to be imported, while reserves only amount to one-tenth of the world average. France, however, is relatively well endowed with water power. Last year, 22·4 thousand million kilowatt-hours were generated with a flow of water 10 per cent. above the average. The coal equivalent of the total power consumption is 2·3 tons per head of population, compared with 8 in the United States, 2·8 in Germany, 1·8 in the Soviet Union and 4·7 tons in Great Britain.

Since 1944 strenuous efforts have been made to increase the national production of coal and, in 1952, the previous highest figure was exceeded. The output per underground manshift increased from 1·21 tons in 1938 to 1·43 tons in 1952 as a result of improvements, including mechanisation at the coalface. Arrangements are being made for transferring miners from the Nord and Pas de Calais fields, where reserves are being exhausted, to the Valenciennes, Douai and Hénin-Liétard regions, where they are still relatively large. The future development of the Lorraine field, where the seams are thick and the coal hard and of high volatile content, demands mechanisation and will be helped by large-scale carbonisation processes that will enable the output to be used by the neighbouring iron and steel industry. Much effort has been devoted to the mechanical preparation of raw coal owing to the high proportion of ash, which amounts to more than 30 per cent. as mined. In this connection, there is the question of finding a use for the middlings, the intermediate product from the machines, and for the slurry that settles out of the washery water. By pulverising the middlings and drying the slurry, however, a fuel is obtained which can be used in power stations at the pit-head. By 1960, it is expected that these power stations will be generating 12 thousand million kilowatt-hours per annum, 7·5 thousand million of which will be sold to the "grid" and the rest used in the mines themselves.

The consumption of gas in 1952 was 95 thousand million cubic feet, an increase of 45 per cent. over the figure for 1938. Conditions have been influenced by the fact that, as France is deficient in coking coals, they have been used largely for the manufacture of metallurgical coke. As a result, the newly-constructed coke ovens are heated by producer gas or rich blast-furnace gas, the gas produced being passed to a continually extending distribution system. Research has also been undertaken on the complete gasification of coal in producers, the chief obstacle to which is the cost of production. Small works for the production of town gas are being eliminated progressively, the area served being either connected to a larger system or to a propane or propanised-air installation. There is also a tendency to replace gasworks by coke ovens capable of producing metallurgical fuel.

The consumption of electricity in France rose to 40·8 thousand million kilowatt-hours in 1952, compared with 21 thousand million in 1938. Of the former amount, 22·4 thousand million kilowatt-hours were produced in hydro-electric stations, or rather more than the estimated average of 20·4 thousand million. In a year of average flow the production is about equally divided between hydro-electric and thermal sta ions. It is estimated that the total potential of French hydro-electric power is about 80 to 90 thousand million kilowatt-hours per annum, although it is pertinent to point out that the capital cost of developing this will increase. The construction programme of thermal power stations is concentrated either in the neighbourhood of the mines or in the Paris area and the spectacular progress which has been made in their design will have the effect of greatly reducing the expenditure on fuel. Continual progress has also been made in the utilisation of electricity. Some 2,640 miles of railway have been electrified, with the result that the annual saving of fuel exceeds three million tons.

As regards the use of solid fuel, consumer preference places graded anthracites and low-volatile coals, which are burnt in central-heating boilers or industrial stoves, in the forefront of demand. The shortage in native production of these fuels has hitherto been met by imports, but there are now numerous obstacles to this course. To meet the position the production of briquettes, especially of ovoids, from low-volatile coals has been developed. The use of graded coke in central-heating boilers is being encouraged and researches are being conducted into the production of a smokeless fuel by low-temperature carbonisation. Promising results have been obtained in the use of coals with a high volatile content for heating. Several plant manufacturers are collaborating with producers in studying the problem of dealing with the large volume of volatiles liberated during combustion, and it is hoped that one or more solutions will be found in the near future. Numerous studies have been conducted to obtain equipment in which the handling and feeding of coal and the cleaning and removal of ash will cause the minimum trouble.

Contractors have now become important in domestic heating. These concerns install new equipment or renovate or improve existing equipment either for an overall fee for the season or for a graded price per calorie. They also undertake to supply fuel and are therefore interested in obtaining efficiency. The policy of adapting fuel and plant to the prevailing conditions of supply is now well co-ordinated by liaison between the interested parties. Laboratories are constantly exchanging results and the plant that comes on the market is provided with a label when it has undergone severe tests by the Plant Manufacturers' Association. In many districts non-profit-making associations have been set up to give the domestic consumer the technical help he may need.

* Paper read before the Institute of Fuel on Thursday, November 5. Abridged.

TURBO-ELECTRIC OIL TANKER "HELIX."

THE turbo-electric ship Helix, shown in Fig. 1, on page 620, which has just completed her sea trials, is the first of 51 general-purpose tankers to be built for the Anglo-Saxon Petroleum Company, Limited. She is claimed to be the safest oil tanker yet built and is fitted with a number of new devices for the safety and comfort of personnel, for the preservation of freight and stores, and for the hastening of her turn-round at ports. The deadweight capacity of the tanker is 18,000 tons. She will be able to trade at more than 200 oil ports. The Helix has been built to the classification requirements of Lloyd's Register of Shipping for Class ✠100 A1 ships "for carrying petroleum in bulk," and to the regulations of the Ministry of Shipping. Prior to approving the designs, prototype models of the hull were subjected to extensive tests in the ship tank at the National Physical Laboratory, Teddington.

The Helix was built at the Wallsend-on-Tyne shipyard of Swan, Hunter, and Wigham Richardson, Limited, and was launched on January 16, 1953. The general particulars of the vessel are as follow: length, 530 ft.; moulded breadth, 69 ft. 3 in.; moulded depth, 39 ft.; load draught, 29 ft. 8½ in.; gross tonnage, 12,000 tons; and her service speed is 14½ knots. Designed in the accepted lines for modern oil tankers, the propelling machinery is located aft; the eleven cargo tanks are bounded at each end by cofferdams and subdivided longitudinally by two bulkheads. The main oil-fuel bunkers have been located both forward and aft of the main tanks, with additional storage in the double-bottom tanks below the machinery. Above the main fuel bunkers forward there is a small hold for carrying cased cargo. The principal pump room is situated at the aft end of the cargo tanks with a smaller compartment forward for the ballast pumps and the transfer pumps.

The construction is of a longitudinal system of framing along the bottom and along the deck over the extent of the cargo tanks, with normal transverse framing on each side in the wing tanks, and conventional transverse framing at the ends of the ship. She has a raked stem and a cruiser stern, with the usual tanker-type poop, bridge and forecastle erections. Welding has been adopted for practically the whole of the steel structure, as is the builders' normal practice. To combat corrosion, a special painting technique was specified by the owners; the outside of the hull had first to be flame-cleaned with oxy-acetylene burners and the priming coat applied while the plates were still warm. The full number of coats of bituminous and oleo-resinous paints, as well as the anti-fouling composition, were then applied before launching.

CARGO-HANDLING EQUIPMENT.

All cargo spaces are fitted with finned cast-iron steam-heating coils. The coils, made by Colvin-Smith, Limited, Team Valley, Gateshead-on-Tyne, and described in some detail in our issue of May 8 last, page 601, enable the cargo to be maintained at or raised to 140 deg. F. so that it is readily pumped.

In order to handle expeditiously the several different grades of petroleum crudes and refined spirit that she is likely to be carrying at any time, the Helix has been equipped with a double ring-main pipeline. With the four turbo-driven centrifugal pumps located in the single pump room the arrangement is flexible and is of equal capacity to that of any existing tanker. The four main cargo pumps are of the Drysdale vertical-spindle centrifugal two-stage type, each having a discharge rate of 400 tons per hour. The pumps are located in the pump room, but the steam turbines which drive them are mounted, as shown in Fig. 2, on vertical shafts, and are situated in the adjacent machinery room. In addition to these high capacity pumps, two high-head stripping pumps have been installed: one, a Drysdale rotary pump driven by an electric motor and the other a vertical steam-driven pump made by Hayward-Tyler, Limited, Luton. The driving units for the main pumps are located in the engine room on a flat 18 ft. above the keel, so

reducing the risk of petroleum entering the engine room in the event of partial flooding of the pump room.

A number of innovations in detail design have been introduced into the cargo-handling equipment of the ship. For example, the relief valves on the cargo pumps are loaded by compressed air, instead of springs, and, in addition to relieving excess pressure, are used to control the output of the pumps. With the relatively low-head capacity of the cargo pumps, it was imperative that friction in the pumping lines should be kept as low as possible and as it was desirable to reduce the time required for cleaning the grids of the strainer boxes in the mains, the sludge receptacles shown in Fig. 3 were adopted. These boxes can be opened, being fitted with quick-action catches, and cleaned, without the use of tools. Novel connections for the flexible hoses, as shown in Fig. 4, opposite, have also been fitted, and these are expected to reduce the time required to make the vessel ready for unloading. To expedite the cleaning-out of the cargo tanks, the Helix has been equipped with portable hoists for raising the sediment to be discharged overboard.

Steam Generation.

The principal steam-generating plant consists of two water-tube boilers fitted with superheaters, tubular air heaters and automatic-combustion control, all supplied by Babcock and Wilcox, Limited, Farringdon-street, E.C.4, and built into the vessel by the Wallsend Slipway and Engineering Company, Limited. These boilers have been designed for a working pressure of 450 lb. per square inch and a steam temperature of 750 deg. F., both measured at the outlet of the superheater. The steam is used for driving the main turbo-alternator sets, described below, the cargo-pump turbines, air-ejectors, the turbo-feed pump and the pump embodied in the Butterworth tanker-cleaning equipment.

The two boilers are arranged to operate under forced draught, the fans being supplied by James Howden and Company, Limited, Newcastle-upon-Tyne. Arrangements have been made to burn low-grade residual fuels having a specific gravity (at 60 deg. F.) of 1·06, a melting point of 165 deg. F., a flashpoint of 400 deg. F., a viscosity (Redwood No. 1) of 20,000 sec. at 212 deg. F. and a higher calorific value of about 17,600 B.Th.U. per pound. The oil burners operate on the Swinney pressure-jet system. Soot-blowers have been provided for cleaning the boilers, superheaters and air heaters.

In an endeavour to reduce the frequency with which the heating surfaces of the boilers have to be cleaned, the fuel is purified by removing the insoluble ash before the oil is fed to the furnaces. The oil is first passed into the main settling tank and then drawn off through a heater which raises the temperature to 180 deg. F. at which the viscosity is sufficiently reduced to permit the separation of the solid matter and water. Two distinct separating units have been installed: a centrifugal machine, employing continuous sludging assisted by the circulation of slightly warm sea-water and supplied by Werkspoor N.V., Amsterdam, and a unit comprising two bowl-type centrifuges made by the Alfa Laval Company, Limited, Brentford. From the separators the oil is taken to final reserve tanks before being passed through the heaters to the furnaces. Arrangements have been made so that experiments on an operational scale can be undertaken on the fuel oils used.

Propelling Machinery and Auxiliaries.

The Helix is propelled by turbo-electric machinery driving a single four-bladed propeller to give an all-the-year average speed of 14½ knots. The main engines, for which all the electrical equipment has been designed and supplied by British Thomson-Houston Company, Limited, Rugby, develop a maximum of 8,300 shaft horse-power, and a service power of 7,500 shaft horse-power at 100 r.p.m. of the propeller. They comprise two turbo-alternator sets each consisting of an impulse turbine directly coupled to a two-pole alternator supplying three-phase current to a motor which is directly connected to the propeller shaft. The condensers, of the regenerative type, are mounted one below each turbine, and each is able to maintain a vacuum of 28½-in. Hg., when sea-water at 75 deg. F. is being circulated and the machinery is developing full service power.

Each propeller motor frame supports two electrically-independent units, the rotors of which are mounted on a common shaft each stator being supplied separately by one of the turbo-alternators. Each of the sets is rated at 2,900 kVA (at unit power factor), 3,000 volts three-phase at 3,000 r.p.m., which corresponds to a shaft speed of 100 r.p.m. The alternators, like the double-unit propulsion motors, have totally-enclosed air circuits, the air being cooled by passing it through a heat exchanger in which sea-water is circulated. As the propulsion turbines are mechanically independent of the propeller drive, the system permits the removal of a main turbine for overhaul and its replacement by a duplicate unit. Lubrication of the machinery is effected by two motor-driven oil pumps, each delivering 4,800 gallons per hour at 85 lb. per square inch gauge; each pump unit is provided with oil coolers and filters and is capable of meeting the requirements of both sets.

Auxiliary power at sea is generally provided by one of two 700-kW geared turbo-alternator exciter sets made by British Thomson-Houston Co., who also supplied several of the smaller motors and their associated control gear, as well as the main and

TURBO-ELECTRIC OIL TANKER "HELIX."

SWAN, HUNTER, AND WIGHAM RICHARDSON, LTD., WALLSEND-ON-TYNE.

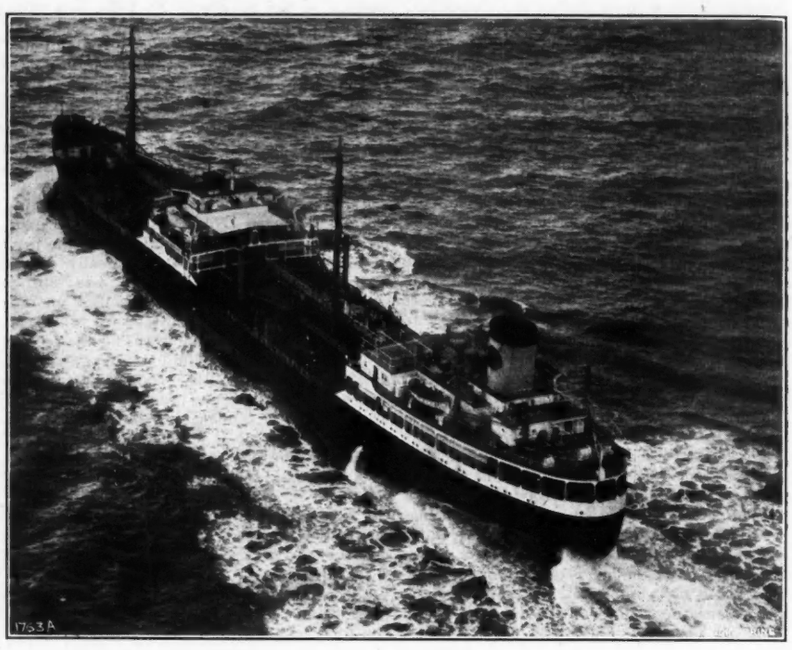

Fig. 1. Turbo-Electric Tanker "Helix."

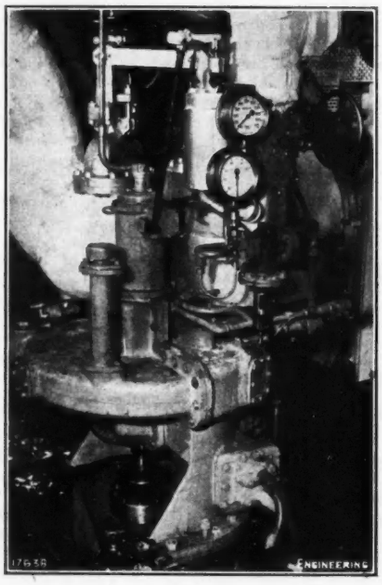

Fig. 2. Vertically-Mounted Turbine Driving Cargo Pump.

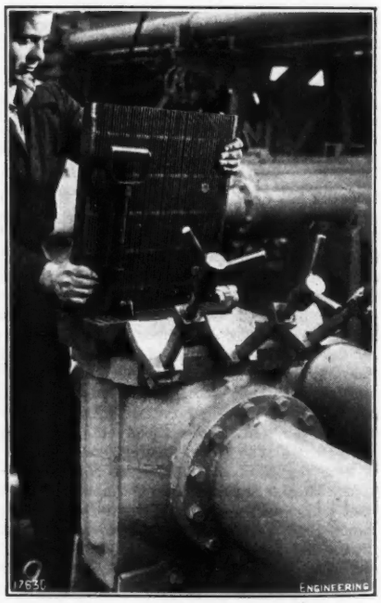

Fig. 3. Sludge Receptacle and Strainer Plate in Oil-Cargo Line.

TURBO-ELECTRIC OIL TANKER "HELIX."

SWAN, HUNTER, AND WIGHAM RICHARDSON, LTD., WALLSEND-ON-TYNE.

FIG. 4. QUICK-RELEASE CONNECTION FOR FLEXIBLE HOSE.

FIG. 5. OVERSIDE LIFT FOR CREW AND FREIGHT.

secondary distribution switchboards. An emergency Diesel-driven alternator set has also been installed. For general work on deck, much of the machinery is steam-powered; this includes the Emerson Walker capstans, and a number of winches used in conjunction with several derricks. The four 24-ft. steel lifeboats (one with an auxiliary motor) have been supplied by A. Gregson and Sons, Bury, and are carried on Welin Maclachlan gravity davits. The steering gear is of the electro-hydraulic type working on the Hele-Martineau principle, the equipment being supplied by MacTaggart Scott and Company, Limited, Loanhead, Midlothian. Normally, the gear is controlled from the wheelhouse by transmitter and telemotor, and is driven by two electrically-driven variable-delivery pumps, each of which is capable of turning the rudder through its full range. The change-over from telemotor to mechanical steering requires no more than the removal of a locking pin.

PRESSURE VENTILATION.

The dangers of fire or explosion due to the presence of free petroleum vapour has been reduced by the installation of a system of pressurised ventilation throughout the ship. Each part of the Helix is sealed, and air at a pressure slightly above atmospheric is supplied by motor-driven fans to each division, after passing through a purification unit incorporating canisters filled with activated carbon. The main entrances to all machinery spaces are in the form of air locks and the natural ventilation openings have sealing flaps which lift only at a pre-selected air pressure.

Under normal sailing conditions, these flaps are locked in the fully-open position, the fans are isolated from the air-purification units and air to meet the requirements of the prevailing climate is supplied through the trunking system which is common to both pressure and normal ventilation. When, however, there is likely to be petrol vapour in the atmosphere, the pressure ventilation system is brought into operation, the intakes of the fans being located well above deck level on the poop erection, where there is little danger of inflammable vapours being drawn in. The intakes are, however, fitted with an automatic-detection system which will, in the presence of a potentially dangerous concentration of vapour, automatically cause the air supply to be passed through the filter system, ring alarm bells and illuminate warning signs so that the necessary precautions may be taken. The scheme, promoted and specified by the owners, has been designed and installed by R. B. Stirling and Company, Limited, Govan, Glasgow.

ACCOMMODATION.

The officers' accommodation is located on the bridge deck, together with the hospital and stewards' rooms: the captain's room and the pilot's room are in the house above, on the upper bridge deck. The wireless room is situated on the navigating bridge adjacent to the chart room and the wheelhouse. The navigational aids include gyro compass and gyro-pilot installations, echo-sounding apparatus, an electric log, wireless and the latest radar equipment. Accommodation for the crew is arranged in single-berth cabins on the upper deck aft, with the customary amenities, including separate mess rooms and a recreation room. The junior engineers and the catering-staff are housed on the poop deck where the galley and the dining saloon are situated. The house on the boat deck has been assigned to the chief engineer and his senior assistants.

The wall lining throughout all the officers' and crew's quarters is of Formica-faced Marinite panels which are both easily cleaned and fireproof. Alternating current has been used throughout the ship for both power and lighting. In addition to the warm air circulated by the pressurised ventilation system, low temperature radiant-heating panels have been fitted in the several lounges and recreation rooms. A system of loud-speaking telephones has been installed throughout the ship. Altogether, the furnishings and decoration of all the living quarters represent the maximum degree of comfort attainable; a permanent swimming bath has been constructed on the poop deck.

An electrically-operated overside lift—one on each side of the vessel—operates from the bridge deck and is to be used for hoisting and lowering ship's personnel and stores. The car being lowered down the side of the ship is shown in Fig. 5, above. Fabricated from light alloys, it can carry about six men or 10 cwt. of stores without any guide rails. The car runs on four wooden wheels which bear against the ship's side. Embodied in it is an articulated rack which, as the car is lowered, extends, thrusting the car away from the ship's side. This piece of equipment has the advantage of providing no means of access to the ship for rats. It has been built for the owners by Clarke, Chapman and Company, Limited, Gateshead.

The basic design and the detailed specification of the Helix is the work of Mr. John Lamb of the Marine Research and Development Department of the Anglo-Saxon Petroleum Company, Limited, St. Helen's-court, London, E.C.3.

THE LATE MR. W. R. RAWLINGS.—We note with regret the death of Mr. William Robert Rawlings, which occurred at his home in Wimbledon, London, S.W.19, on October 18. Mr. Rawlings, who was a director of the Rawlplug Co., Ltd., which he had developed in conjunction with his brother, the late Mr. J. J. Rawlings, was born at Roehampton, Surrey, in 1864. He was educated at St. Mark's School, Chelsea, and at the City and Guilds Institute. After serving as works manager of the Waring Cable Co. for two years, from 1886 to 1888, he entered into partnership with Mr. J. J. Rawlings to form the firm of Rawlings Bros., electrical engineers and contractors. The concern was incorporated as a limited company in 1900 and Mr. W. R. Rawlings was chairman and managing director of the firm and of its subsidiary companies for many years. In 1904, he was elected the first President of the Electrical Contractors' Association and served again in this capacity in 1914-15 and 1931-32. The Rawlplug Co., Ltd., was registered in November, 1919. Mr. Rawlings was made an associate of the Institution of Electrical Engineers in 1891 and was elected an associate member in 1899.

DUAL LIGHTING IN A BRASS FOUNDRY.—One of the factors which led to the installation of combined tungsten and mercury lighting units in the brass foundry of Hayward-Tyler & Co., Ltd., Luton, was that the low contrast between the colour of the light and that of the brass enables a high level of illumination to be provided without glare from the castings. The scheme was designed by the General Electric Co., Ltd., Kingsway, London, W.C.2, to give an average illumination of 60 lumens per square foot on the black sand floor. It comprises 24 dual units, each containing one 1,000-watt and one 400-watt mercury lamp in a fitting with large top and side openings to permit the passage of air. The accumulation of dust is thus prevented, as is shown by the fact that at the end of five months the light obtainable was 2·4 times that from a closed-top vitreous-enamel fitting and 1·33 times that from a fitting with a vitreous-enamel reflector and ventilated canopy. The fittings are suspended in four rows of six at 22 ft. above the floor and with a spacing of 15 ft. between fittings and between rows. Owing to the height of the bays the fittings are supported from catenaries which are stretched between the tie beams.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

RURAL ELECTRIFICATION.—The South-East Scotland Electricity Consultative Council agreed in Edinburgh on November 2 to recommend to the South-East Scotland Electricity Board that 164,000*l.* be expended in rural development in 1954-55 in the southern sub-area, which consists of Roxburgh, Selkirkshire, much of Peebleshire, and part of Midlothian. Mr. James Rutherford, of Hawick, chairman of the Council's local committee for the southern sub-area, pointed out that there was still about 80 per cent. of the area not electrified.

THE ROYAL YACHT "BRITANNIA."—The Royal Yacht, Britannia, of 4,700 tons, which was launched by John Brown & Co., Ltd., last April, went down the river Clyde on November 3 preparatory to undergoing builders' speed trials over the measured mile off Arran. Thereafter she will carry out further trials for ten days. These preliminary trials will be followed by official sea trials off Arran towards the end of the year.

ENGINEERING MODEL EXHIBITION, GLASGOW.—The Glasgow Society of Model Engineers are to hold an exhibition in the Christian Institute, 70, Bothwell-street, Glasgow, from November 28 to December 5. The exhibition will be open from 10 a.m. until 10 p.m. daily.

FACTORY FOR INSULATING MATERIAL, STIRLING.—Production is expected to start next month in the new factory of the Cape Asbestos Co., Ltd., Stirling. The firm are to produce an insulation product, "Rocksil," made from a combination of rock from Duror, Argyll, and clay from deposits at Bonnybridge. The product will be mainly used in shipbuilding, but is also recommended for thermal insulation and other projects. The factory involves a capital expenditure of 250,000*l.*

IMPROVEMENTS TO TARBERT PIER.—Tarbert (Loch Fyne) Harbour Board are seeking increased borrowing powers and a Government grant estimated at over 20,000*l.* to meet the cost of improving the old outer pier. It has been suggested that, in order to finance the project, harbour and pier dues may have to be increased substantially.

CLEVELAND AND THE NORTHERN COUNTIES.

HOME CONSUMPTION AND EXPORT OF COAL.—The need for economy in the use of coal for home consumption if Britain is to build up export trade, was referred to by Col. E. G. Angus, presiding at a meeting at Newcastle-upon-Tyne of the Newcastle and Gateshead Chamber of Commerce. He pointed out that, in 1938, foreign shipments from the Tyne were over 8,000,000 tons and coastwise shipments, 4,600,000 tons. In 1950 coastwise shipments reached over 7,200,000 tons, but overseas shipments only 2,276,000 tons. Last year they were 7,400,000 tons and 1,835,000 tons, respectively. These figures showed a steady increase in home consumption and a fall in exports. Coal sent coastwise was merely a book-keeping transaction between the National Coal Board and the gas and electricity authorities, whereas coal exported brought in foreign currency.

INDUSTRIAL SITES IN NEWCASTLE AREA.—At the monthly meeting of the Northern Regional Board for Industry at Newcastle-upon-Tyne, Mr. K. G. Sillar, Regional Controller for the Board of Trade, stated that two firms outside the Northern Region were investigating the possibilities of industrial sites in the area. During August and September, industrial development certificates relating to a floor area of over 441,000 sq. ft. had been approved and these would provide work for 347 men and women. Employment in Government-sponsored factories in the Northern Region had reached its highest figure at 46,085.

TYNE SHIPBUILDING.—There will be only one launch on the River Tyne this month, bringing the river's output for the first 11 months of the year to 23 vessels aggregating 203,600 gross tons, compared with 21 vessels totalling 161,702 tons in 1952 and 31 comprising 214,638 tons in 1951. November's solitary launch will be the 9,450-ton passenger and cargo liner Pacific Northwest, which Vickers-Armstrongs Ltd. are building for Furness Withy & Co.

FUTURE DEVELOPMENTS OF W. GRAY & CO.—The annual report of Hartlepools Chamber of Commerce referred to the proposal of William Gray & Co., Ltd., local shipbuilders and marine engine builders, to develop their works on the Tees rather than in the Hartlepool area, and said that this had somewhat darkened shipbuilding prospects for the district. The report stated that there was enough shipyard work to last two years, but, beyond that date, the outlook was not encouraging.

REDUNDANCY OF MINERS IN NORTHUMBERLAND.—A Haltwhistle (Northumberland) business man has suggested that local industrialists should try to establish a new light industry locally to provide employment for miners who are likely to become redundant within a few years. The National Coal Board have intimated that pits in the area have only a limited life and notices have been posted at collieries urging miners to accept work in other areas, chiefly in the Midlands.

TANKER BUILT IN HALVES.—A tanker of more than 18,000 tons deadweight carrying capacity, on order for the Norwegian firm of Rolf Wigand, is being built in halves at Sunderland by Messrs. John Crown & Sons, Ltd. When the first section is ready for launching, it will be necessary to demolish part of a quay wall to get the ship into the water. Messrs. Crown's is the smallest shipyard on the Wear.

LANCASHIRE AND SOUTH YORKSHIRE.

STEEL MANAGERS IN CONFERENCE.—Steelworks managers from Yorkshire, Derbyshire and Lincolnshire have been meeting in conference for a week at Matlock to discuss a variety of topics affecting their task and to suggest solutions of difficulties which are frequently encountered. Four further conferences are to be held before Christmas; they are organised by the West Riding and North Derbyshire Area Training Committee of the British Iron and Steel Federation.

COAL STOCKS.—Yorkshire collieries are consistently yielding a weekly output of over a million tons of coal. It is officially stated that the Sheffield and Rotherham Division of the East Midlands Gas Board has sufficient coal in stock to last five weeks. This is regarded as reasonably satisfactory, and is better than the average for all gas undertakings in the East and West Ridings. Stocks held by electricity undertakings are sufficient to last 6·3 weeks. Gas and electricity undertakings are consuming more coal than last year, but industrial undertakings are taking less.

NEW ROLLING MILL.—With the object of improving quality rather than increasing production, the firm of Swift, Levick & Sons, Ltd., Clarence Steel Works, Sheffield, 4, have installed their first rolling mill. The firm will now have complete control over all the processes that go into the making of their steels. Hitherto the rolling has been done for them by other firms.

TRADE WITH SOUTH AFRICA.—Sheffield manufacturers are not perturbed by the decision by the South African Government to end its preferential treatment of sterling area imports next year by allowing many goods in from the dollar area. Mr. W. G. Ibberson, of George Ibberson & Co., and Senior Warden of the Cutlers' Company, states that he welcomes the decision on the ground that, quality for quality, and cost for cost, Sheffield can compete with America. He regards any move which tends to lead to improved multilateral trade as a good thing.

THE LATE MR. F. M. PARKIN.—Mr. Frederick Michael Parkin, who died on November 2 at his home in Dore-road, Sheffield, at the age of 71, was chairman and managing director of F. M. Parkin (Sheffield), Ltd., steelmakers, a business which he founded.

THE MIDLANDS.

PETROLEUM PLANT MANUFACTURE IN THE MIDLANDS.—Fears that the approaching completion of the large petroleum-refining plants in Great Britain might lead to a surplus of plant manufacturing capacity in the Midlands were dispelled by Mr. Walter Kohring, chief engineer of the Vacuum Oil Company's Coryton Refinery, who spoke in Birmingham on October 28. Addressing the annual meeting of the Midland Region of the Council of British Manufacturers of Petroleum Equipment, Mr. Kohring said that the refining industry was in a state of flux, and that new developments might quickly make the most modern equipment obsolete. He also referred to the rise of the petro-chemical industry, and pointed out, in addition, that refineries needed extensive maintenance, which would bring extra business to plant manufacturers.

SUGGESTED CLOSURE OF CANAL.—Suggestions that the southern part of the Oxford Canal, from Braunston Junction to Oxford, should be closed and abandoned are being opposed by the Inland Waterways Association. The northern part of the canal, from Braunston to Hawkesbury, near Coventry, forms part of the through route from London to Birmingham and the north, and is in no danger of abandonment at present.

MIDLAND FIRM'S CANADIAN BRANCH FACTORY.—Ratcliffs (Great Bridge) Ltd., Eagle-lane, Great Bridge, Tipton, Staffordshire, are opening a branch factory in the Toronto area of Canada. The company are makers of rolled brass and copper strip, and are starting their new factory to supply these products to Canadian motor manufacturers. Hitherto, most of the brass and copper strip used in Canada has been imported from the United States.

DERAILMENT OF GOODS TRAIN.—The derailment of 16 coal wagons, which were being shunted on the London Midland Region main line from Birmingham to Manchester, on October 31, caused traffic to be diverted for several hours. The derailment took place at Harborne Junction, where a single track leaves the main line to serve a suburb, and a considerable length of track was damaged. Traffic was diverted temporarily over the old Grand Junction line, which by-passes Birmingham on the north side.

MACHINE-TOOL DEMONSTRATION.—A demonstration of modern machine tools and equipment is to be held at the Birmingham office of Alfred Herbert Ltd., 208, Corporation-street, Birmingham, 4, from November 16 to 21 from 10 a.m. to 6 p.m. daily. The demonstration will include high-speed bar work, chuck work, milling, grinding, and inspection procedure. All interested persons are invited to visit the demonstration.

THE LATE MR. C. J. SARJEANT.—We regret to announce the death on November 3 of Mr. Cyril John Sarjeant, who before his retirement in 1949 for reasons of health, was manager of the control-gear engineering department of the British Thomson-Houston Co., Ltd., Rugby. Mr. Sarjeant was born at Balham, London, on August 10, 1891, and joined the British Thomson-Houston Co. in 1911 as an assistant in the test department. In August, 1914, Mr. Sarjeant joined the Royal Field Artillery, took part in the Suvla Bay landing in Gallipoli and later saw service in France until May, 1918, when he was made a prisoner of war. He returned to England in December, 1918, and rejoined the British Thomson-Houston test department in June, 1919. A few months later, however, he transferred to the control-gear department. In 1925, Mr. Sarjeant went to South Africa to supervise the final installation of the 3,000-volt direct-current automatic substations of the South African Railway electrification scheme. He was appointed manager of the control-gear engineering department in September, 1947, succeeding Mr. H. C. Hastings.

SOUTH-WEST ENGLAND AND SOUTH WALES.

INDUSTRIAL SITES AT CARDIFF.—Inquiries have been received from three concerns—one of them the Unilever Company—for industrial sites in Cardiff. These inquiries were the direct outcome of the recent visit to the city of the Transport Users' Consultative Committee. It is reported that the Unilever Company require a site of 30,000 sq. ft.

HIGH ROLLING-MILL OUTPUTS.—A new output record was set up by the slabbing mill of the Richard Thomas and Baldwins Works, at Ebbw Vale, in the week ended October 31. The total tonnage rolled was 12,193, the previous record being 12,106 tons, reached in April last. The Steel Company of Wales have announced that the five-stand cold-reduction mill at Trostre, Llanelly, rolled 8,220 tons in the week ended October 31. This is the highest tonnage so far achieved. The previous highest tonnage rolled was 7,580 tons in the week ended October 10.

LABOUR POSITION IN TIN-PLATE INDUSTRY.—Capt. H. Leighton Davies, the chairman, told a meeting of the Swansea and District Employment Committee that such a change had come over the Welsh tin-plate trade that there was now insufficient labour to man the mills and further operatives would have to be brought over from Italy. There had been a great improvement in the employment position since June. Short-time working had almost disappeared in the tin-plate industry and most of the men made redundant by the closing of the old hand mills had been absorbed in other industries.

WELSH BRICK-MAKING INDUSTRY.—A record output of bricks in Wales was attained in September, it was reported at a meeting of the East Wales District Committee of the Welsh Board for Industry. Altogether 29,800,000 were made, of which East Wales contributed 13,000,000.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, November 16, 5.30 p.m., Victoria-embankment, W.C.2. Discussion on "Illuminations and Decorative Lighting," opened by Mr. H. Carpenter. *Mersey and North Wales Centre:* Monday, November 16, 6.30 p.m., Town Hall, Chester. "Telemetering for System Operation," by Mr. R. H. Dunn and Mr. C. H. Chambers. *Measurements Section:* Tuesday, November 17, 5.30 p.m., Victoria-embankment, W.C.2. "Alternating-Current-Instrument Testing Equipment," by Dr. A. H. M. Arnold. *East Midland Centre:* Tuesday, November 17, 6.30 p.m., Electricity Showrooms, Derby. "Diesel-Electric Locomotives," by Mr. G. E. Smith. Tuesday, November 17, 7 p.m., University Arms Hotel, Cambridge. "Electricity Applied to Mining," by Mr. C. D. Wilkinson. Thursday, November 19, 7.30 p.m., George Hotel, Kettering. "Electricity in Farm Crop-Drying," by Mr. C. A. Cameron Brown and Mr. F. G. Finn-Kelcey. *London Students' Section:* Tuesday, November 17, 7 p.m., Public Library, Chelmsford. "Metallic Resistance at High Frequency," by Mr. A. D. Stevens. *Utilization Section:* Thursday, November 19, 5.30 p.m., Victoria-embankment, W.C.2. "Wear of Carbon Brushes at High Altitudes," by Mr. R. F. Sims. *South Midland Centre:* Thursday, November 19, 7.15 p.m., Winter Gardens Restaurant, Malvern. "Printed and Potted Electronic Circuits," by Mr. G. W. A. Dummer and Mr. D. L. Johnston.

INSTITUTE OF PACKAGING.—*Midland Area:* Monday, November 16, 6.30 p.m., Imperial Hotel, Birmingham. "Tensional Strapping," by Mr. B. Field. *Yorkshire Branch:* Wednesday, November 18, 6.30 p.m., Metropole Hotel, Leeds. "Packaging of Newton Chambers & Co., Ltd.," by Mr. J. Connell.

INSTITUTION OF THE RUBBER INDUSTRY.—*Merseyside Section:* Monday, November 16, 7 p.m., Electricity Showrooms, Whitechapel, Liverpool. "Plastics and the Rubber Industry," by Mr. S. Mottram. *Scottish Section:* Tuesday, November 17, 7.30 p.m., 39, Elmbank-crescent, Glasgow. Discussion on "Rubber in the Motor Trade."

INSTITUTION OF PRODUCTION ENGINEERS.—*North-Eastern Section:* Monday, November 16, 7 p.m., Neville Hall, Newcastle-upon-Tyne. Discussion on "Use of Radial Drilling Machines for Boring Work." *Manchester Section:* Monday, November 16, 7.15 p.m., College of Technology, Manchester. "Modern Power Plants for Helicopters," by Captain A. G. Forsyth. *Oxford Section:* Monday, November 16, 7.15 p.m., Randolph Hotel, Beaumont-street, Oxford. "Increased Productivity with Present Equipment," by Mr. S. Erskine-Murray. *Halifax Section:* Tuesday, November 17, 7.15 p.m., George Hotel, Huddersfield. "5-in. Sliding, Surfacing and Screw-Cutting Lathes," by Mr. D. H. Turnbull. *Birmingham Section:* Wednesday, November 18, 7 p.m., James Watt Memorial Institute, Birmingham. "High Precision in Quantity Production," by Mr. J. Smedley. *Gloucester Section:* Wednesday, November 18, 7.15 p.m., Bell Hotel, Gloucester. "Application of Motion Study," by Miss A. G. Shaw. *Edinburgh Section:* Wednesday, November 18, 7.30 p.m., North British Station Hotel, Edinburgh. "Tyre Manufacture," by Mr. A. J. MacTaggart. *Dundee Section:* Wednesday, November 18, 7.30 p.m., Mathers Hotel, Dundee. "Watchmaking," by Mr. A. W. Marshall. *Glasgow Section:* Thursday, November 19, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "Metal Finishing and Hard Coating," by Mr. S. A. J. Murray.

INCORPORATED PLANT ENGINEERS.—*Merseyside and North Wales Branch:* Monday, November 16, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Fan Engineering," by Mr. R. H. Holbecke. *South Wales Branch:* Tuesday, November 17, 7.15 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Discussion on "Mechanical Handling." *Glasgow Branch:* Wednesday, November 18, 7 p.m., 425-427, Sauchiehall-street, Glasgow. "Heat Transfer," by Mr. R. A. Brecknell. *Kent Branch:* Wednesday, November 18, 7 p.m., Bull Hotel, Rochester. "Concrete," by Mr. E. Davis. *Western Branch:* Wednesday, November 18, 7.15 p.m., Grand Hotel, Bristol. Open Meeting. *Blackburn Branch:* Thursday, November 19, 7.30 p.m., Grosvenor Hotel, Blackburn. "Electrical Hazards," by Mr. D. A. Picken.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS.—Monday, November 16, 7.30 p.m., The University, St. George's-square, Sheffield. "Indentation Hardness," by Dr. D. Tabor.

INSTITUTION OF ENGINEERING INSPECTION.—*Wolverhampton Branch:* Monday, November 16, 7.30 p.m., Compton Grange, Compton-road, Wolverhampton. "Precision Lost-Wax Castings," by Mr. W. N. Jones. *Dundee Branch:* Wednesday, November 18, 7.30 p.m., Royal British Hotel, Dundee. "Principles of Measurement," by Mr. G. V. Stabler.

INSTITUTE OF REFRIGERATION and PHYSICAL SOCIETY (*Low Temperature Group*).—Tuesday, November 17, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Freeze Drying," by Drs. R. A. Kekwick and R. F. Strickland-Constable.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 17, 5.30 p.m., Great George-street, S.W.1. "Construction of Two Concrete-Lined Tunnels for the Machkund Hydro-Electric Project, South India," by Mr. G. A. Gauld and Mr. R. J. Newport. *Yorkshire Association:* Wednesday, November 18, 6.15 p.m., Electricity Showrooms, Ferensway, Hull. Film Evening. Friday, November 20, 7 p.m., Hotel Metropole, Leeds. "Atmospheric Pollution," by Dr. A. Parker.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Scottish Branch:* Tuesday, November 17, 6 p.m., Ca'doro Restaurant, Glasgow. "Examples of Structural Steel Design," by Mr. V. H. Lawton. *Yorkshire Branch:* Wednesday, November 18, 6.30 p.m., Great Northern Hotel, Leeds. "Prestressed-Concrete Beams at London Airport," by Mr. A. J. Harris.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, November 17, 6.30 p.m., 39, Elmbank-crescent, Glasgow. "Application of Conveyors to the Handling of Materials in Bulk," by Mr. J. Findlay.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, November 17, 6.30 p.m., Magnet House, Kingsway, W.C.2. "Electrical Developments in Horticulture," by Mr. F. E. Rowland.

WOMEN'S ENGINEERING SOCIETY.—*London Branch:* Tuesday, November 17, 7 p.m., 35, Grosvenor-place, S.W.1. Discussion on "The Comet Aeroplane."

INSTITUTE OF BRITISH FOUNDRYMEN.—*East Anglian Section:* Tuesday, November 17, 7 p.m., Public Library, Ipswich. "Sands," by Mr. A. P. Lovat. *North-East Scottish Section:* Wednesday, November 18, 7.30 p.m., Imperial Hotel, Arbroath. Film Evening. *Bristol and West of England Branch:* Saturday, November 21, 10.45 a.m., Grand Hotel, Bristol. "Machine Tool Castings," by Mr. G. W. Nicholls.

INSTITUTION OF MECHANICAL ENGINEERS.—*Western Branch:* Tuesday, November 17, 7 p.m., Grand Hotel, Broad-street, Bristol. "Recent Developments in the Machinability of Steel," by Mr. K. J. B. Wolfe. *Midland Branch:* Thursday, November 19, 6 p.m., James Watt Memorial Institute, Birmingham. "Influence of Industrial Design on Engineering," by Mr. F. D. Hollister and Mr. John Barnes. *Institution:* Friday, November 20, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Thomas Hawksley Lecture on "Relaxation Methods: A Retrospect," by Sir Richard Southwell, F.R.S. AUTOMOBILE DIVISION.—*Scottish Centre:* Monday, November 16, 7.30 p.m., 39, Elmbank-crescent, Glasgow. "The Jaguar Engine," by Mr. W. M. Heynes. *North-Eastern Centre:* Wednesday, November 18, 7.30 p.m., The University, Leeds. "Commercial Vehicle Problems," by Mr. G. H. Lee.

INSTITUTION OF WATER ENGINEERS.—*South-Eastern Section:* Wednesday, November 18, 2.30 p.m., Institution of Civil Engineers, Great George-street, S.W.1. "Wells and Boreholes," by Mr. H. A. P. Hetherington.

ROYAL SOCIETY OF ARTS.—Wednesday, November 18, 2.30 p.m., John Adam-street, W.C.2. "The First President," by the Earl of Radnor.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 18, 5 p.m., 49, Cromwell-road, S.W.7. Various short papers.

INSTITUTION OF CHEMICAL ENGINEERS.—Wednesday, November 18, 5.30 p.m., Caxton Hall, S.W.1. Film Evening.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, November 18, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Developments in Locomotive Testing," by Mr. S. O. Ell.

INSTITUTE OF FUEL.—*Yorkshire Section:* Wednesday, November 18, 6.30 p.m., The University, Leeds. "Recovery and Use of Rejected (Waste) Heat in Industry," by Mr. S. J. Eardley.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, November 19, 2.30 p.m., Caxton Hall, S.W.1. "Noise: Practical Aspects," by Mr. J. E. Holton.

ROYAL SOCIETY.—Thursday, November 19, 4.30 p.m., Burlington House, Piccadilly, W.1. Annual Report of Council. Short papers on "Diamonds."

INSTITUTION OF MINING AND METALLURGY.—Thursday, November 19, 5 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. (i) "Performance of Percussive Drills," by Mr. W. R. Cheetham and Mr. E. W. Inett; and (ii) "Surface Diamond Drilling Problems and Practice in Northern Rhodesia," by Mr. D. C. J. Squirrell.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 20, 7 p.m., Townsend House, Greycoat-place, S.W.1. Chairman's Address on "A Consulting Engineer's Casebook," by Mr. S. R. Broderick.

PERSONAL.

THE RT. HON. LORD BILSLAND, M.C., D.L., LL.D., has been elected a director of John Brown and Co. Ltd., Clydebank, Dunbartonshire.

AIR COMMODORE G. J. POWELL, C.B.E., managing director of Silver City Airways Ltd., 1, Great Cumberland-place, London, W.1, has been elected chairman of the British Independent Air Transport Association for the second year in succession.

SIR ROGER DUNCALFE, chairman of British Glues and Chemicals Ltd., has been elected to succeed VISCOUNT WAVERLEY, P.C., G.C.B., G.C.S.I., G.C.I.E., F.R.S., as President of the British Standards Institution, 2 Park-Street, London, W.1.

MR. R. H. WEIR, B.Sc., A.F.R.Ae.S., at present director of engine research and development, Ministry of Supply, will officiate as principal director of engine research and development as from January 1, 1954. He will succeed AIR COMMODORE F. R. BANKS, C.B., O.B.E., who will return to his firm, The Associated Ethyl Co. Ltd., but will remain a consultant to the Ministry on aeroplane engines.

MR. J. VAUGHAN HARRIES, M.I.E.E., President of the Association of Mining Electrical and Mechanical Engineers, has been installed as chairman of the Western Centre of the Institution of Electrical Engineers.

MR. KENNETH DOUGLAS, fitting-out manager of Vickers-Armstrongs Ltd., Walker-on-Tyne, has been appointed deputy general manager of William Gray & Co. Ltd., West Hartlepool, as from January 1, 1954. We understand that he will succeed MR. EDWIN GRAHAM as general manager, when the latter retires later on in 1954.

MR. ALEXANDER FINDLAY, B.Sc.(Glas.), has been appointed superintendent marine engineer of Cable and Wireless Ltd.; he will be responsible for the maintenance of the company's fleet of eight cable ships.

MR. T. M. AYRES has been made deputy chairman of the North-Eastern Electricity Board. He has been with the Board and its predecessor, the North-Eastern Electric Supply Co. Ltd., since 1935.

MR. V. P. MACKAY, M.I.E.S., A.I.E.E., has been made manager, rotating-plant department, Bruce Peebles & Co. Ltd., Edinburgh, 5. MR. R. W. FLUX, A.M.C.T., A.M.I.E.E., has been appointed manager, and MR. D. H. SMITH, B.Sc.(Eng.), A.M.I.E.E., chief designer and deputy manager, transformer department. MR. O. L. ROBSON, M.B.E., B.Sc.(Eng.), M.I.E.E., is to be manager, rectifier department.

MR. R. A. LIDDLE, superintendent engineer, Canadian Pacific Steamship's, Ltd., Gladstone Dock, Liverpool, 20, has retired after 43 years of service with the company. His successor is MR. T. S. HILL.

MR. F. LAYTON has been appointed to take charge of the sales administration department, Northern Aluminium Co. Ltd., Banbury, Oxfordshire. He is to be succeeded as manager, Leeds area sales office, by MR. H. M. LOUCH. Mr. Louch's present position as sales development manager is to be held by Mr. E. D. ILIFF, at present publicity manager. The publicity division will now be in the charge of MR. R. F. TAYLER.

MR. D. C. G. LEES has left the Aluminium Development Association to join Aluminium Union Ltd., as development engineer.

MR. G. W. ROBERTSON, sales manager, Solignum Ltd., Donington House, Norfolk-street, Strand, London, W.C.2, has been elected a director of the company.

The British Productivity Council announce that MR. G. M. FLATHER has been nominated a director of the National Industrial Fuel Efficiency Service.

WINSTON ELECTRONICS LTD., Hampton Hill, Middlesex, have acquired GOSWELL & Co., Alpha-road, Teddington, whose principals, MR. A. G. GOSWELL and MR. F. HILDRED, are remaining with the company, which is to be known in future as WINSTON METAL FABRICATIONS, LTD.

THE HOYT METAL CO. OF GREAT BRITAIN LTD., Deodar-road, Putney, London, S.W.15, have now a wholly-owned subsidiary company operating in Australia: HOYT ALLOYS AND CHEMICALS OF AUSTRALASIA PTY. LTD., 82, Pitt-street, Sydney, New South Wales.

George Pike Ltd., Equipment Works, Alma-street, Birmingham, 6, announce that MR. T. J. GODDARD has left their service and that MR. R. S. EMERY has been appointed the new manager for Scotland, at Equipment Works, Bishopbriggs, Glasgow.

WICKMAN LTD., Coventry, have opened a London branch factory and offices at Oxgate-lane, Cricklewood, N.W.2.

As from November 2, arrangements have been made whereby the METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester, 17, have taken over the manufacture, sale and servicing of resistance welding and heating machines formerly manufactured by BRITISH INSULATED CALLENDER'S CABLES LTD.

CENTRIFUGAL-CASTING FOUNDRY, SHEFFIELD.

(*For Description, see Page* 629.)

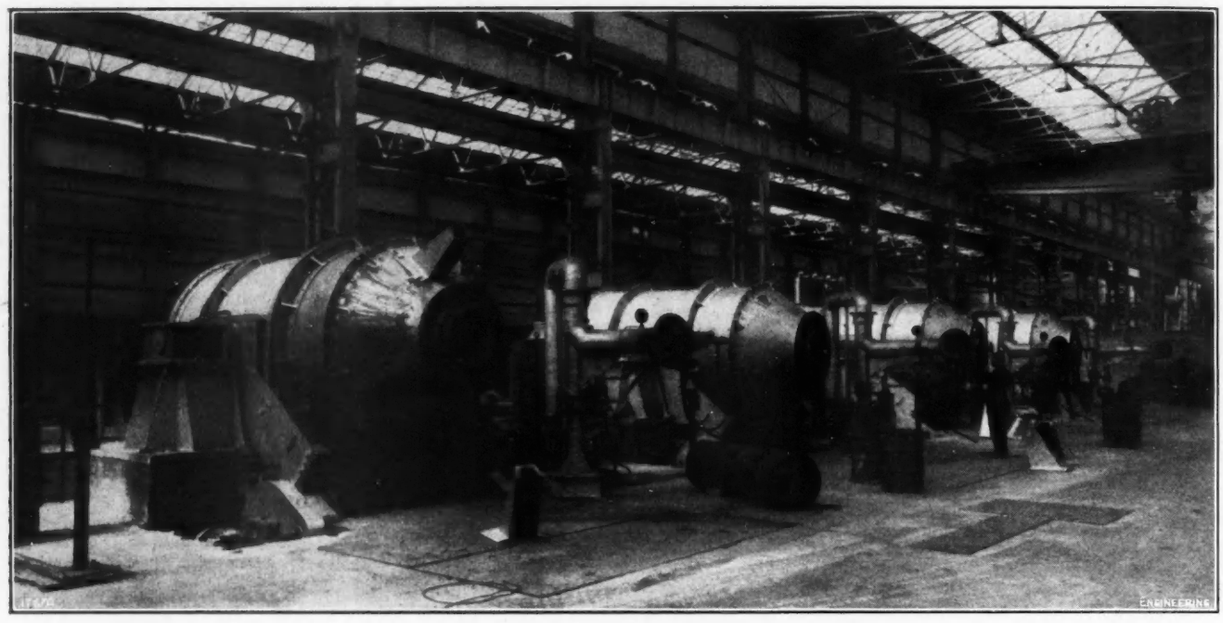

FIG. 1. BATTERY OF OIL-FIRED ROTARY TILTING FURNACES.

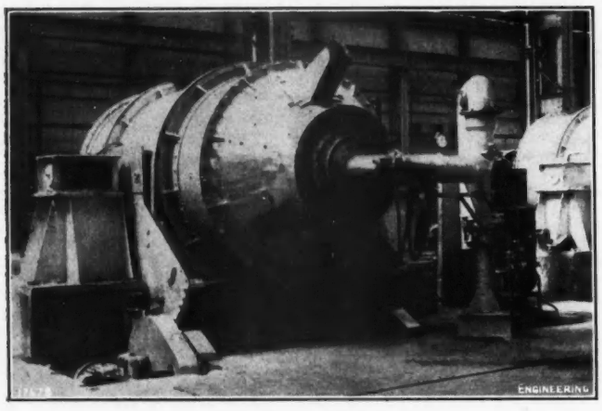

FIG. 2. FURNACE BURNER IN CLOSED POSITION.

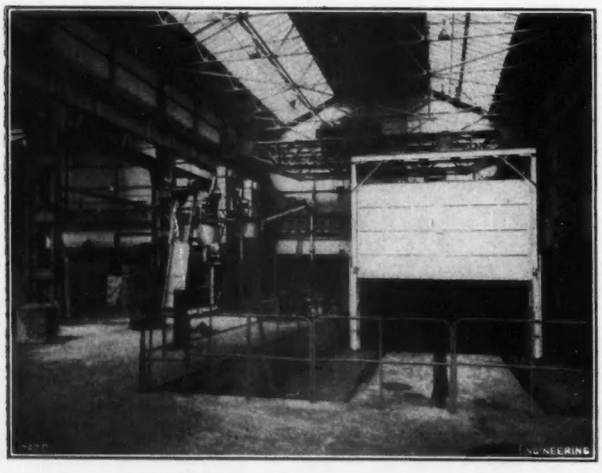

FIG. 3. SAND PLANT, RAMMING PIT AND MOULD STOVE.

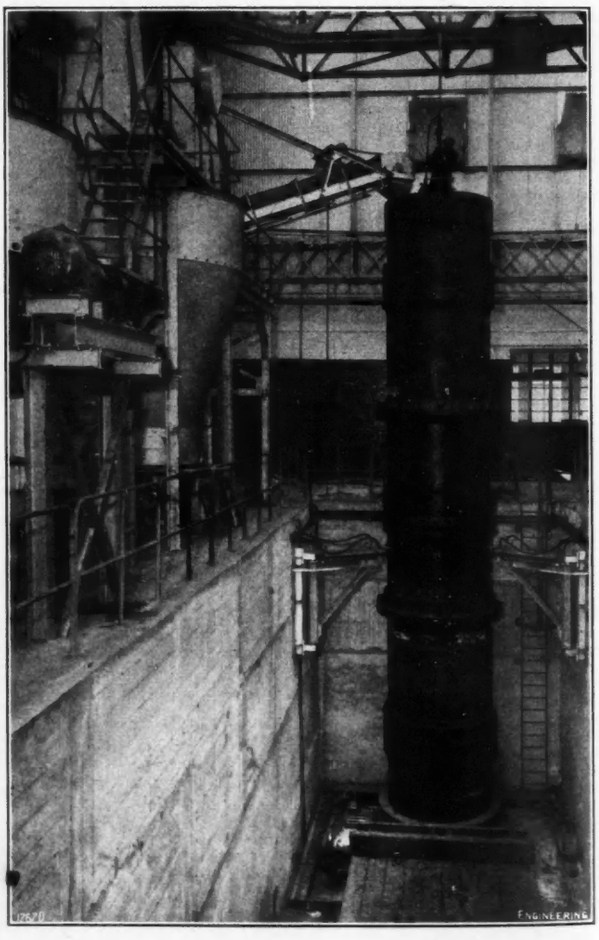

FIG. 4. CYLINDRICAL CASTING FLASK IN RAMMING PIT.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, NOVEMBER 13, 1953.

VOL. 176. No. 4581.

SAVING TIME IN THE DRAWING OFFICE.

IN the drawing office it is all too easy to spend more time on a job than is really necessary. Draughtsmen themselves cannot fail to be aware of this danger, but if a particular job has taken an unexpectedly long time to complete, it is difficult for the senior draughtsman to decide whether time has been wasted or the work has simply required extra thought and inquiry. There are two distinct phases in designing: the mental phase, in which the designer conceives the required form and construction; and the drawing phase, in which he puts his conception on paper in a manner which will convey his intentions to the production department. Only in the case of very simple components are the two phases separate, one following the other. Usually the two develop alternately in the mind and on the drawing board, since, in the case of a complicated design, it is seldom possible to visualise the finished design until the work is nearing completion and the details, in relation to the whole scheme, have been determined.

The work involved in the drawing phase can be reduced by as much as 30 per cent., according to a book which has been written by two members of the staff of the General Electric Company, in the United States.* They contend that conventional drawing-office practice leads to a waste of valuable time in drawing unnecessary lines, views and details, and that if this time were saved the designer would be more free to devote his attention to his proper work. Their methods have been adopted in the United States by the General Electric Company. Two examples of the resulting economy may be quoted: a drawing which previously required 57 sq. ft. of paper was replaced by one of less than 4 sq. ft.; and a drawing which formerly took eight days to produce was done in two days. In a company which previously used 75 million square feet of drawing reproduction paper, the aggregate economies are evidently large.

Simplified drawing is already universally accepted in, for example, the use of conventionalised oblique lines for screw threads (though this method can be further simplified by using two straight dotted lines denoting the bottoms of the threads). Similarly, where a standard or familiar component such as a pipe, a union, a channel section, or even a standard pressure gauge, is to be denoted, a simple line of the right shape, or an agreed symbol, can be employed. Read in conjunction with the catalogue number or other identifying legend, this is sufficient to convey the draughtsman's intentions to the producer. A drawing of a drilled plate will not require an end elevation if its thickness (the only dimension not shown in the plan) is indicated. A pipe of standard section can be specified by giving a diameter and the length. There is no point in drawing an end view of, say, a channel section—with its four radii and tapering flanges—if the section is standard. Even if the end view must appear in, for example, an assembly or general arrangement drawing, there is no reason why it should not be replaced by a single line in the shape of a channel section. The authors commend to draughtsmen the slogan "Superfluous line is a waste of time."

The book gives examples of drawings which have been prepared by the old and the new methods. The difference is remarkable, and makes it quite clear that the change recommended, based on practical experience of it, is a fundamental change rather than a slight modification to existing practice. The saving in time and cost is substantial, not marginal. Since assembly drawings are normally intended to indicate the relation of one part to another, that purpose can often be achieved satisfactorily by very simple drawing conventions. It is absurd to draw with painstaking care the details of a component which is repeated twenty times in the design. Sometimes a symmetrical part can be shown by drawing only one half of it.

These are some of the authors' tricks. An even greater change is the adoption of free-hand drawing. Ordinary drawing instruments are practically discarded for this type of work, and the draughtsman draws on squared paper. The finished job is only approximately to scale, but in any case the production shops follow the dimensions given. The squared paper carrying the original drawing can be used directly for reproduction purposes, without tracing, if it is done on paper with the co-ordinate guide lines printed in non-actinic blue ink. The authors emphasise the fact that a draughtsman need not be an artist to undertake free-hand drawing; the examples they illustrate show that quite complicated drawings can be executed in this way. They also describe the application of special templates for quickly drawing the symbols which replace the detailed drawings, and they explain some novel ways of using photography to save time in the drawing office. They have assuredly carried their argument to its logical conclusion. The old coloured and shaded drawings of former years have long since become *objets d'art* in engineering; now, it seems, their successors—the functional but still realistic drawings in bold black and white—are to go too. It is hard to suppress an expression of regret, but it is no use protesting; the change is apparently inevitable. It may not lead to better drawings, but perhaps it will lead to better designs. Can it be that the authors are making a virtue of necessity: that in the United States there is a shortage of good draughtsmen?

* *Simplified Drafting Practice: A Modern Approach to Industrial Drafting.* By W. L. Healy and A. H. Rau. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York, 16, U.S.A. [Price 5 dols.]; and Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 40*s.* net.]

PARALLEL OPERATION OF PUBLIC AND PRIVATE ELECTRICITY SYSTEMS.

As is well known, the electrical power requirements of British industry are not supplied exclusively from the public mains, some being still obtained from plant installed on the premises of the user. Nevertheless, the proportion of public and private supplies has moved steadily in favour of the former, so much so that it has been estimated that whereas the total electricity consumed by industry in 1948 was 84 per cent. more than in 1935, the amount that was privately generated was only 15·6 per cent. greater. Moreover, this increase occurred without any marked change-over from private generation to public supply; in other words, it was to be ascribed to such factors as availability, convenience and perhaps most of all to a desire to conserve capital. The result has been that there are to-day few cases where private plant is operated without any form of supplementary or stand-by supply from the public system.

This state of affairs has both its economic and its technical aspects, added to which the shortage of public generating capacity has led sometimes to misunderstandings and disagreements between the owners of private plants and the Area Boards. This side of the problem was discussed by Mr. O. Howarth in an article which appeared on page 230 of our 174th volume (1952), in which he pointed out that it was erroneous to suppose that either the British Electricity Authority or the Boards were opposed to the installation of private generating plant, but that these bodies were entitled to demand a fair price for the services provided, often under unfavourable conditions. Moreover, they were prepared to buy any surplus energy which the owners of private plant might have at their disposal. Since then, in fact, the Boards have neutralised some of their critics by implementing the recommendation of the Ridley Committee that restrictive conditions in old contracts on the use and installation of private generating plant should be abandoned. Indeed, they have agreed, where necessary, to enter into new contracts which would merely reflect the costs of connection and supplying the consumer, while leaving him free to use his own plant as he wishes.

Even in this atmosphere of greater freedom, however, there remain certain technical difficulties to be taken into consideration; for, as pointed out by Mr. Howarth, where privately owned plant is operated in parallel with a Board's system, care must be taken not to jeopardise the functioning of either or to expose the staffs to danger. To ensure against risk of accidental shock, stringent rules regarding safety must be laid down with which all concerned must comply and the employees of the private consumer must obey the instructions of the Board's engineer, who at all times must be regarded as responsible for the switching and operating programme. This being so, the British Electricity Authority have taken the wise course of preparing, in association with the Federation of British Industries and the National Union of Manufacturers, a memorandum which lays down certain principles for the guidance of users of private generating plant. It consists of a brief review of the more important technical aspects of parallel operation and covers the majority of the conditions that are met with in practice.

Dealing first with generating plant, it is pointed out that synchronous and asynchronous alternators, as well as direct-current dynamos, are all suitable for operation in parallel with the public system. When these generators are driven by reciprocating engines cyclic variation may occur, but, generally speaking, these will cause no difficulties on the public system, although they may be serious enough to prevent parallel running. In the case of synchronous generators, synchronising equipment will have to be installed at the point of connection between the private plant and the mains. Moreover, where a consumer desires to be able to parallel both at his own generator switch and at the incoming feeder switch, the necessary equipment should be arranged so that it can be used on either. The consumer's staff should receive sufficient instruction to enable them to appreciate any change in the electrical conditions during running, and to take the right action in emergency. Most industrial users use single-phase supplies drawn from each phase and neutral, and a medium-voltage generator feeding such a load must generate a practically sinusoidal wave so that its neutral point and the neutral wire of the Board's network can be interconnected. Since it is generally economically impracticable to design generators having outputs of less than 100 kW with sinusoidal wave-forms, such plant can rarely be directly operated in parallel with the network. Further, depending on its capacity, it may be necessary to provide automatic voltage regulation on the generator to ensure that the voltage of the public system is maintained within stability limits. Asynchronous generators are simpler to operate than synchronous generators, the main problem being the compensation of the low power factor owing to the magnetising current being drawn from the public mains. As regards direct-current plant, the consumer's plant must have similar loading characteristics to that of the Board's plant with which it is to operate in parallel.

An important section of the memorandum is devoted to the control of power factor. It is pointed out that the plant operated by the Central Authority and the Area Boards is designed to cater for a power-factor range of 0·75 to 0·85, within which that of industrial loads normally falls. If, however, supplies have to be given to plants operating outside that range, special provisions must be made which not only affect the capital costs incurred by the Boards, but the efficient control and operation of the system. For instance, where a consumer's generator is running in parallel with the mains and supplies the whole of the consumer's load, it must be operated at a power factor not higher than that of the the latter, otherwise the Board's system will have to carry a disproportionate amount of the consumer's wattless current. It is important, therefore, that the power factor at which the consumer operates his plant should be in accordance with a figure agreed with the Board.

Further, the protective arrangements must be such that when a consumer's generator becomes defective it will immediately be disconnected from the Board's system. Similarly, provision must be made for the disconnection of the consumer should any fault occur on the mains. Otherwise, the private generator might continue to feed into the fault or maintain circuits alive which would be dead if there were no private generation. The relevant provisions of the Electricity Supply Regulations, 1937, regarding earthing, must also be complied with and the Area Boards must finally be satisfied that the paralleling of the public system with a private generator shall not impose a short-circuit duty on any switchgear in excess of its assigned rating. Where calculations show that it would be overstressed, the position may be alleviated by sectionalising or by using an operational routine which will reduce the short circuit to a tolerable amount.

The requirements laid down in this memorandum, which we have briefly summarised, may seem to be unduly stringent. It must be remembered, however, that both parties to these operations own a great deal of expensive plant and in the case of the Area Boards, have also the responsibility of maintaining a supply to thousands of consumers. It is essential, therefore, that adequate precautions should be taken.

NOTES.

THE JOINT IRON COUNCIL.

A SUGGESTION that the iron industry's contribution to the revenue of the British Cast Iron Research Association might be increased, so that a corresponding reduction could be made in the Government's contribution, was made by the Minister of Supply, the Rt. Hon. Duncan Sandys, M.P., at the annual banquet of the Joint Iron Council, held at the Dorchester, London, on November 3. Mr. Sandys said that one of the reasons for the industry's success was that it had recognised, for many years, the value of scientific research. The Government recognised the importance of the part which the Association played in industrial life, and contributed 40 per cent. of the revenue. He was not sure, however, that that was altogether a healthy situation. The Government were completely sincere in their desire to promote the prosperity of the industry. Pig-iron production, including iron for steel-making, was running at the annual rate of 7,000,000 tons in 1945; in 1952 it had increased to 10¾ million tons. As for iron castings—at the end of the war about 2½ million tons per annum were being made; in 1952, no less than 3¾ million tons were made, worth 250*l.* millions. That was a great achievement of which the industry could be truly proud. Mr. Sandys concluded his speech with an announcement that, after consulting the Iron and Steel Board, he had decided to abolish price control over all castings and forgings; the Order would take effect next month. The toast of "Her Majesty's Government," to which the Minister was replying, was proposed by the President of the Joint Iron Council and chairman of the Council of Iron Producers, Mr. F. Scopes. Addressing particularly the representatives of the iron and steel industry present, Mr. Scopes said that in all essentials they now had an Act on the Statute Book (the Iron and Steel Act, 1953) which gave them what they wanted; or perhaps it would be more accurate to say an Act which gave what the great majority had for several years been saying they wanted. It was now up to everyone of them to do everything they could to make the Act work, and work really well.

GLASGOW UNDERGROUND RAILWAY.

The Glasgow Underground Railway, which extends for 6½ miles under the city, was opened in January, 1897, and was at first operated by private enterprise on the cable system. It was taken over by the Corporation in 1923 and was converted to electric traction 12 years later. In 1947, a proposal was made to extend it so that it would serve the eastern side of the city, but no action was taken, one of the obstacles being that it is laid on a 4-ft. gauge. It is now announced that the Corporation Transport Committee, on the suggestion of the manager, Mr. E. R. L. Fitzpayne, have decided again to inquire into the possibility and have authorised consultation with Sir William Halcrow and Partners on the matter. While no particular extension is contemplated at this stage, the traffic needs of the city are increasing and on some roads saturation is being reached. This is particularly the case in the new housing areas, which it is becoming increasingly difficult to provide with essential transport. Although there is considerable support for seeking expert advice, the prospect of meeting the high costs of the necessary tunnelling is viewed locally with some alarm, and once again the question of gauge has raised a difficulty. In this connection, it has been suggested that the new extension need not be physically linked with the existing system, but that interchange facilities between sections by lifts or other means might be provided.

SAFETY IN MINES.

The hazards of explosions, fire and pneumoconiosis, together with the possibility of a variety of mechanical failures of plant and equipment, are among the subjects that were investigated during 1952 at the Ministry of Fuel and Power's establishment for research into safety in mines. The thirty-first annual report, covering the activities of

the establishment during that year, has been published recently and copies can be obtained from H.M. Stationery Office [price 3*s.* net]. The likelihood of both explosions and pneumoconiosis is primarily due to the dust content of the atmosphere in the mine workings and considerable effort was expended in efforts to determine more about the production of the dust, the phenomena of its deposition and dispersion, and to develop the means of controlling it. A specific investigation has shown that the quantity of dust produced in unit time by a rotary drilling machine is roughly proportional to the speed of revolution and, if this speed is held constant, that the dust produced per unit length of drilling is inversely proportional to the rate of penetration. It follows that, for the minimum production of dust, it is advantageous to use low speeds of revolution and to obtain high rates of penetration by employing sharp bits and high thrust loads. The relative merits of laying and immobilising coal dust by the use of stone-dust, salt and water-sprays have also been examined. Water is preferred to stone dust because it has a higher heat capacity, it is readily applied either as a coarse spray or as a fine mist (the direction and continuity of application of which can be determined) and it is cheaper. But it is noted that many problems still have to be resolved before water can be used for this purpose, whereas stone-dust barriers are ready for immediate application by the mining industry. The deposition and re-dispersion of dust due to prevailing air currents moving with velocities of between 75 and 400 ft. per minute have been studied in a small wind tunnel; it has been found that every particle of respirable size which makes contact with a surface, whether clean or dirty, sticks and is retained and can only be re-dispersed by direct physical interference by air moving in excess of 400 ft. per minute. On the engineering and metallurgical side, the establishment continued with the introduction of instruments and equipment for non-destructive testing of components; the newly-acquired equipment included a magnetic crack detector, an ultrasonic flaw detector, an iridium container providing a 500-millicurie source of gamma rays, and films for obtaining radiographs. This equipment has proved itself most useful when searching for hair cracks in plant but so many were found that some differentiation had to be made between cracks that were harmless and those in regions of high stress where they represented a potential danger. The development has also continued of new types of adjustable or yielding pit prop in which the upper strut is held in position above the foot by a system of friction plates and wedge clamps. The report is concluded by a brief synopsis of the fifty research reports and papers published by members of the staff of the establishment during 1952.

THE BRITISH COUNCIL.

The report of the British Council for the year ended March 31, 1953, explains that though much of this body's work is concerned directly or indirectly with achievements in the sciences and engineering, it is limited by two important factors. In the first place, the Council does not deal with commercial aspects, although what is done naturally has some indirect effect on industrial relations. Secondly, it only addresses itself to specialist groups, such as professional associations, universities and technical colleges, and makes no attempt to interpret science to the general public overseas. Within these limits it provides facilities for personal contact between scientists and distributes scientific material. Personal contact is achieved by sending scientists abroad to give lectures, to attend conferences or to work in overseas universities, as well as by receiving visitors in the same category. Students are also placed. Examples of this liaison are visits to this country of a Council scholar from the Argentine, who came to study quantum electrodynamics, an Austrian professor of railway and tunnel engineering and an inspector of mines from Ceylon. An exhibition of specialised instruments and equipment, showing their use in research, was held in Paris, and an urgent request from Brazil for a supply of radioactive isotopes was successfully met. A good deal of published matter is interchanged and there is close co-operation with the Department of Scientific and Industrial Research and other scientific bodies in this country. The field covered is, of course, very wide, but it may be mentioned that the courses and study tours organised in this country included one on television and another on the engineering aspects of public health. The price of the report is 2*s.* 6*d.* net and copies are obtainable from the offices of the Council, 65, Davies-street, London, W.1.

BRITISH GEAR MANUFACTURERS ASSOCIATION.

At a luncheon of the British Gear Manufacturers Association at the Piccadilly Hotel, London, following the presentation of the paper by Mr. Balmforth (see page 632) the toast of the guests was proposed by the chairman, Mr. J. E. Skidmore. The reply was made by Captain (E) W. A. Stewart, R.N., Assistant Engineer-in-Chief, Admiralty. Captain Stewart said that his work dealt with high-power turbines. As the present ratio of little ships to big ones in the Navy was about 60 to 1, the importance of space was becoming very great, and a premium was being set on compactness. This, in turn, meant higher speed engines, Diesels, turbines and gas turbines, with a consequent need for reduction gears. In naval work, circulatory systems of lubrication were in use, and contamination by water was a constant problem. He assured the Association that the Navy were not prejudiced against any particular form of gearing, and were prepared to use straight or epicyclic gears according to the application. With the reduction in size and increase in speed of the prime-mover, the gearing now often made up half the total weight of the power unit. Consequently the most compact form of gearing was to be preferred. Research work had led them to decide to use hardened and ground gears up to 7 ft. in diameter. It was important to balance design, manufacture and lubrication factors to ensure complete reliability.

OBSOLETE PRODUCTION EQUIPMENT IN THE UNITED STATES.

The American Society of Tool Engineers, which describes itself as "The technical society of the men with 'Production Know-How,'" has recently conducted a coast-to-coast survey in the United States of the percentages of obsolete or inadequate production equipment in use by American industry at the present time. For the purpose of the survey, firms were divided into the four groups: small (employing 250 persons or less), intermediate (employing up to 1,000 persons), large (employing up to 5,000 persons), and very large (employing over 5,000 persons). The various processes were divided under the headings of machining, handling of materials, inspection and precision control, metal-forming, grinding and finishing, and, lastly, production welding. The collective findings of the survey reveal that 30 per cent. of machining equipment now being used by American industry is considered by industry itself to be obsolete; 34 per cent. of inspection methods are obsolete; 28 per cent. of material handling equipment and processes are either inadequate or completely obsolete; 28 per cent. of the metal-forming processes are regarded by industry as obsolete and in need of modernisation or replacement; 25 per cent. of industry's production welding equipment is admittedly out-dated; and, finally, 23 per cent. of grinding and finishing equipment is either obsolete or worn out. In announcing these results, Mr. Roger F. Waindle, President of the Society, pointed out these figures were industry's own evaluation of the threat to survival in a competitive era, and said "There can be no doubts of industry's deep concern over the threats posed by this obsolete equipment and processes in the stiff national and international competition which industry feels is ahead. There is to-day a growing awareness that new equipment with all the modern accessories is the only answer."

MANUFACTURE OF BLASTING EXPLOSIVES IN INDIA.

As a result of agreements reached between Imperial Chemical Industries Limited and the Ministry of Commerce and Industry of the Government of India, a new company is to be established in India to manufacture that country's requirements of high explosives for commercial blasting operations. The demand for these has increased of late years owing to the development of mining and to the construction of roads, thermal electricity-generation and water-power plants, irrigation schemes and other public works. The company will be known as Indian Explosives Limited, and, initially, Rs. 2 crores (1½*l.* million) of capital will be issued, of which 80 per cent. will be subscribed by I.C.I. Limited, and 20 per cent. by the Government of India. Any further capital required will be met by loans. A site for a factory has been selected near the Bihar coalfield and I.C.I. Limited, through their Nobel Division, will be responsible for planning the layout of the works and providing designs for the plant and equipment. They will also be responsible for its erection and setting to work. The British firm will provide all the technical knowledge required to operate the factory, as well as information on research. Moreover, all the management staff and key employees will be provided by them. The factory will give direct employment to about 400 persons in all, and the parent company have undertaken to train Indians to take over responsible posts. I.C.I. (India) Limited, who, hitherto, have been acting as agents for the import of explosives manufactured by the parent company in the United Kingdom, by agreement with the new company, will handle the distribution and sales of explosives manufactured in India. I.C.I. (India) Limited will also continue to operate the extensive series of magazines which they own throughout the country and will act as secretaries to the new company. The establishment of Indian Explosives Limited adds a new manufacturing activity to those which the parent company undertake in India through their Indian subsidiary company, the Alkali and Chemical Corporation of India, Limited, which produces heavy chemicals and paints, and I.C.I. (India) Limited, which formulates dyestuffs and manufactures plastic film.

ENGINEERING APPRENTICES IN THE COAL MINING INDUSTRY.

The National Coal Board are inaugurating an educational scheme with a view to providing the industry they control with trained mechanical and electrical engineering craftsmen. It involves a co-ordinated course of practical training and technical education, which will extend over five years and has been agreed with the National Union of Mineworkers. This body will be represented on the committees which will advise on the operation of the schemes in each area, interview candidates and recommend boys for apprenticeships. No premium will be charged. The apprentice will receive wages at rates fixed by the Joint National Negotiating Committee of the Board and Union. He will be released from work for one or two half-days a week to attend educational courses, for which fees, travelling expenses and, where applicable, lodging allowances will be paid. These apprenticeships will be open to boys working in the industry and coming from outside. Generally, they will be under 17, although older boys will be exceptionally accepted, of good educational standard and physically suitable. The yearly intake will be governed by the need to maintain the industry's complement of qualified craftsmen and will also depend on the requirements of each Coal Board Division. Vacancies will be notified at the collieries and other Coal Board undertakings as well as at Youth Employment offices and technical colleges.

DEMOLITION OF RAILWAY BRIDGE.—The demolition of the bridge carrying the main line of the Western Region of British Railways from London to Birkenhead over the centre of Shifnal, Shropshire, has proved more difficult to demolish than had been anticipated. The bridge, which was built of cast iron in 1849, is being replaced by a single-span steel structure to sustain the heavier locomotives now used. The existing bridge is bolted together, and it was expected that, on removal of the bolts, it would be possible to lift the sections by crane. It has been found, however, that the joints have "grown" together, and it has become necessary to cut through the cast-iron members, which are 8 in. thick, with flame cutters.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Concluded from page 585.*)

THE concluding paper in the programme of the Autumn Meeting of the Institution of Naval Architects, held in Holland during the week commencing September 14, was presented at the afternoon session on Wednesday, September 16, by Mr. T. W. Bunyan, B.Sc., and was entitled "Investigations of Ships' Hull and Machinery Defects." The chairman, as at the morning session, was Sir Stanley V. Goodall, K.C.B. A summary of Mr. Bunyan's paper is given below.

HULL AND MACHINERY DEFECTS.

Mr. Bunyan's paper described the work done by the research department of Lloyd's Register of Shipping in investigating some selected cases of defects in ships' hulls and machinery, which presented features of technical interest, the main purpose of the paper being to indicate developments made in technique and in instrumentation which were inspired or necessitated by the circumstances of these cases. For example, in studying high-frequency vibrations in gearing, much use has been made of multi-channel recording equipment whereby data can be obtained simultaneously from a number of points—from the pinions, the turbine-rotor shafts, and the main gearwheel. Apparatus for measuring and analysing sound levels, Mr. Bunyan said, had proved "a valuable and versatile adjunct." New methods had been devised for checking the alignment of turbines and gearing, and had proved serviceable in a number of cases, including two in which the trouble was caused by the partial collapse of semi-resilient chocks under the turbine feet. A section of the paper which aroused considerable interest was that dealing with electrical resistance strain gauges, the use of which enabled problems to be investigated which, without their aid, might not have been solved at all; examples cited were complex torsional-vibration investigations, the vibration of a tailshaft under service conditions, the measurement of surface strains on submerged parts such as propeller blades, rudders, underwater shell-plating, etc., and the tightening and running stresses in large bolts in oil engines. Reference was made, also, to some applications in practice of the shaft-alignment indicator described by Dr. S. F. Dorey in 1951, at the Newcastle meeting of the International Conference of Naval Architects and Marine Engineers. Mr. Bunyan concluded his paper with a section on low-frequency vibration and the uses of the Geiger torsiograph. In particular, he cited an instance in which a satisfactory investigation was made of severe trouble arising from propeller-excited hull vibration; axial vibration of the thrust block and a broken tailshaft eventually developed. In this case, the Geiger instrument was used as a low-frequency vibrograph and axial recorder. The cause of the trouble was found to be insufficient clearance in the propeller aperture in the stern frame; it was cured by fitting a shorter tailshaft, thus moving the propeller forward in the aperture, and, at the same time, providing additional stiffening in the engine and thrust-block seatings. In some cases of axial resonance, the author added, the trouble had been cured by fitting propellers having more than the customary four blades; but this he regarded as a "drastic procedure."

DISCUSSION.

The discussion was opened by Mr. R. J. Anderson, who observed that naval architecture seemed to have reached a state already common in other branches of engineering practice, in that the naval architect, while keeping his interest focused on the main issues of design and propulsion, must be aware also of the numerous recent developments round the fringe of his subject. In the field of non-destructive testing, Mr. Bunyan had given some most valuable information; but he had rationed himself severely in the choice of examples of modern techniques. Coming directly under the title of his paper was the variety of instruments based on eddy-current loss principles, which should have been mentioned. One application was for sorting; for example, the differentiation between turbine blades of similar dimensions but different alloy steels, by the determination of the voltages generated by friction between a standard metal and the unknowns—each material having its own characteristic voltage. The most useful application, he thought, was in the inspection, or non-destructive testing, of non-ferrous tubes for condensers, oil and water coolers, etc. A probe, containing two arms of an inductance bridge, was drawn through a tube at a fixed rate of either 12 or 24 ft. per minute, and at the same time a record was made on a strip chart within the instrument to which the probe was attached, depicting the local changes of resistance along the tube caused by pits, holes, dezincification, etc. The interpretation of the results might be influenced to some extent by such factors as hardness and dimensional changes, and hence was a matter of experience; nevertheless, much more rapid and satisfactory testing was thus possible than by the use of an intrascope or any other means of *in situ* inspection, and the withdrawal at random of numbers of suspect tubes for sectioning and internal examination was almost a thing of the past.

Dr. T. W. F. Brown commented that, in connection with sound measurement and analysis, Mr. Bunyan had not made it quite clear that there were two specific types of investigation. First, there was axi-analysis, i.e., merely dividing up the total source of sound into proportions at each octave; but, to try to cure anything, the total source of sound must be worked through a sound analyser, to ascertain the amplitude and frequency generated by each of the excitations. In the case of double-reduction gearing, for example, it might not be possible to find even the particular generator of sound because, as Mr. Bunyan remarked, it might be in the original kinematics of the generating machine—what was known as the "phantom wheel." The original main dividing-wheel in the generating machine might have impressed its imperfections on the resulting gear wheel. In that field, the accuracy attainable was astounding; they would consider that they were erring badly if they were not correct to one in a million, and with care they could be quite sure of achieving an accuracy of one in two million.

The author referred to a noise level of 93 decibels, presumably in a reduction gear; that was a very good figure. The average figure in good practice was about 103. Speaking of hardened and ground gearing, Mr. Bunyan had said that further improvement would be obtained. Undoubtedly, that was so if the gear was operated at the same loading as a "shock" gear; if a shock gear had a Brinell hardness between 190 and 220, and a hardened and ground gear had a Brinell hardness of 450, there was no doubt that the latter would be the quieter. But no one would make a hardened and ground gear, with all the metallurgical problems of distortion, involving hobbing, further hardening and subsequent grinding, to operate at the same load; and if the hardened and ground gear were used to its full capabilities, it was definitely the noisier gear.

A warning which, he felt, should always be given when electric resistance strain gauges were mentioned was that they suffered severely from drift. When using a strain gauge in an experiment over a period of time, it was essential to be sure that strain was being measured and not drift. The strain gauge was at its best in measuring dynamic stresses, going through a zero stress. Mr. Bunyan mentioned the word "static." Trouble was inevitable unless the static was associated with only a very short time interval. Mr. Bunyan advocated the use of the Geiger instrument for measuring low-frequency vibrations, and that was probably wise for ordinary practice; many people used it for measuring torsional oscillations, but it was made for measuring low-frequency oscillations.

With regard to torsional oscillations on geared-turbine systems, in certain cases it was clear that the one and only torsional critical was below the working speed range; but sometimes it was not far enough below, and in certain designs it might be within the speed range. In the two-nodic torsional vibration, even when it came close to the running speed, there was a great deal of automatic damping in the turbine and the gearing, and it was possible to come quite close to a two-nodic vibration in one of the gears without having a very serious increase in torsional stress. With regard to axial vibration of propellers and shafting: in that case there was a large mass in the propeller, and a spring system up to the thrust block, and the calculation was simple; but in measuring axial vibration on board ship it was necessary to use a factor of something like 0·6 to reconcile the measured with the calculated, because a further spring system was interposed between the thrust block and the ship. Had Mr. Bunyan measured the axial vibrations and, if so, what factor in general would he recommend?

Professor E. V. Telfer said that Mr. Bunyan had referred to experiments carried out at the National Physical Laboratory, presumably by Lloyd's Register, in connection with the clearances in propeller apertures. It was disappointing that, apparently, the results of those experiments had not been published. The problem of adequate clearance was a difficult one. On the other hand, adequate clearance was wanted from both the body post and the rudder post, but in doing so, so far as the body post was concerned, there was a tendency to steepen the angle of entrance of flow and to cause a breakdown in front of the propeller; so that giving more clearance caused more trouble with the propeller than would result from coming nearer to the propeller itself, with a smaller angle of entrance into it. For that reason, Dr. Telfer said, he would like to know whether that particular point was explored in the N.P.L. experiments, because the Washington experiments showed that the probable explanation for the experience with series 57 was bad aperture resistance on an otherwise reasonably good hull. Another aspect of aperture resistance was not concerned with fore and aft clearances. He had fitted more than 500 ships, and old ships of every description, with rudder-post fins, and only in very few cases did vibration result from so doing. The type of fin which did produce vibration was the non-streamlined type. Most of the trouble with propeller vibration was due to the assumption that a very wide streamlined rudder, possibly 15 to 18 in. wide, was also streamlining so far as the propeller was concerned. Too much rudder-post clearance put too steep an angle of flow into the propeller. The solution did not lie along those lines, but in slimming the rudder and hence streamlining and reducing the angle of flow into the propeller and the angle of exit from it.

The next point on which the author rather invited criticism was in regard to propellers having an odd number of blades. For the past 18 years, he (Dr. Telfer) had adopted the five-bladed propeller as the solution of many vibration and flow-breakdown problems, and he disagreed with Mr. Bunyan's statement that the adoption of a five-bladed propeller was a drastic move. It might require courage, but it was not a drastic matter, and spectacular cures of bad performance had been obtained by the use of five blades. He was surprised that Mr. Bunyan had found many single-screw ships having only three blades; presumably they were tugs and other small craft, because three-bladed propellers were rare in larger practice. There was a big difference between the horizontal forces introduced by a five-bladed and a three-bladed propeller. He was glad that the author and Lloyd's Register were doing that kind of work; it was really important, and a contribution towards a more comfortable and vibration-free propeller. Tankers presented many problems, and he thought that definite changes in outlook must come about before it could be guaranteed that 22,000 h.p. from a single propeller, with a streamlined rudder, represented the best that could be obtained with a single screw.

Mr. Bunyan, in reply, agreed with Mr. Anderson that instruments based on eddy-current loss principles, for sorting, etc., could be very useful. There were many things he could have mentioned in the paper, but he wanted to keep it straightforward and informative and it was very difficult to decide just what should and should not go in. The value of 93 decibels, referred to by Dr. Brown, was measured under full-power conditions. The equipment was not very large, about 4,000 shaft horse-power. He was interested in Dr. Brown's comments regarding hardened and ground gears

MILLSPAUGH CENTRIFUGAL-CASTING FOUNDRY.

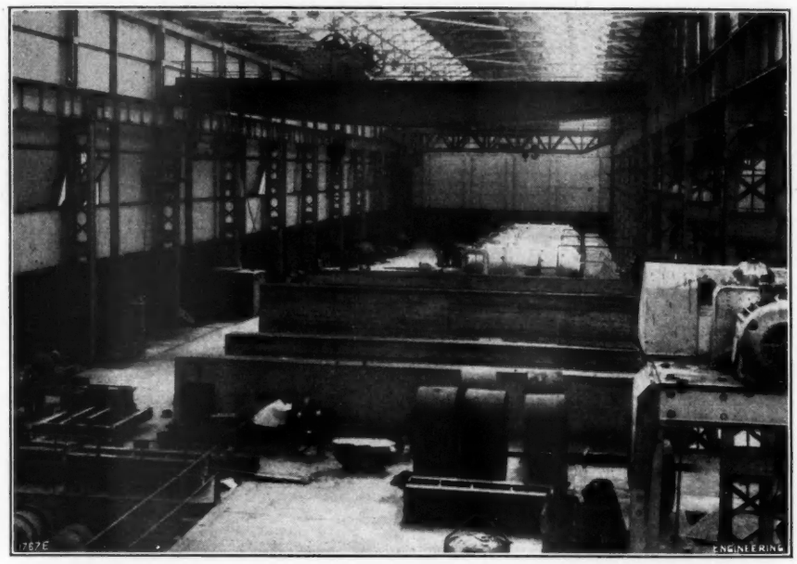

Fig. 5. Horizontal Centrifugal-Casting Machines in Course of Erection.

working at very high K factors; those would come, but without those high K factors it was not an economic proposition.

Lloyd's Register of Shipping was one of the earliest organisations to use the electric resistance strain gauge in the United Kingdom, and they had learned a lot about drift. They would not consider for a moment the use of strain gauges where a static condition was likely to last a week; strain gauges were the wrong things to use in those circumstances. They had made complex stress analyses on fractionating columns for the oil industry, sections of wind tunnels, etc., involving the use of a large number of gauges—300 or 400—and he could assure Dr. Brown that the greatest care was taken to minimise drift. They could guarantee the figures quoted in the paper, and under ideal conditions they could better them.

Dr. Brown asked what was meant in the paper by the "Geiger." It was a mechanical apparatus, giving a direct record. Lloyd's Register had three of them constantly in use. They were not perfect, but they would stand a lot of knocking about, they were easily calibrated and easily stripped down, and they could be made to do many other jobs, for which they could be quite reasonably adapted. He would continue to use the Geiger until something really spectacular and cheap was developed. It might be necessary to send a team at any time, at short notice and with a minimum of apparatus, to the ends of the earth to investigate a serious breakdown. If they had an apparatus that would do four or five jobs and give the answers straight away, it was to be preferred. Investigations might have to be made inside an engine room and the people concerned wanted to be told what must be done, almost at once, so that they must have an apparatus with which they could analyse and pick out the predominating harmonics immediately; that the Geiger would do. On the question of axial vibration, he was not prepared to quote a figure from memory.

In reply to Professor Telfer, he did not know when the work being done at the N.P.L. would be published; it was taking a long time, because it covered a wide field, but he hoped that, some day, they would be able to put forward something valuable, and to synchronise with Dr. Todd on the matter. The problem of aperture resistance had involved much thought. The results of the work spoke for themselves; and the paper showed what a remarkable improvement was attained by attention to the propeller trailing edge and the nose of the finned sternpost. Incidentally, in those ships there was a streamlined sternpost and quite a thin rudder. The whole problem was shrouded in uncertainty, and, as Professor Telfer had said, with large powers it could be extremely acute. He apologised for having given the impression that he had dealt with a large number of single-screw vessels fitted with three-bladed propellers; actually, there were five of them, two being tankers and three the ordinary general-cargo carriers. The improvement was considerable. As to five-bladed propellers, he had merely concluded that, with the eccentric transverse forces, the reactions which might occur with a propeller having an odd number of blades, the transverse bending component for the tailshaft might be more than with a propeller having an even number of blades.

At the end of the discussion, which concluded the technical sessions of the meeting, Sir Stanley Goodall expressed the thanks of the Institution of Naval Architects to the Koninklijk Instituut van Ingenieurs for having arranged for the meetings to be held in the Kurhaus, which had proved so convenient; and to Professor Ir. H. E. Jaeger for his informative opening address and his support at all the meetings.

Electrical Cables for Aircraft.—British Insulated Callender's Cables, Limited, Norfolk House, Norfolk-street, London, W.C.2, have introduced two new wiring cables for aircraft. One of them, Nypren, is a nylon-covered Pren cable resistant to synthetic lubricating oil. It is made the same diameter as the equivalent Pren cable, by reducing the thickness of the insulation covering slightly. At present, Nypren cables are available only in the smaller sizes. The other new cable, Unifire, for fire detection and extinguishing circuits, has compound glass and asbestos insulation impregnated with various silicone compounds, and will operate in open flame at 1,000 deg. C. for not less than five minutes.

Toughened Glass with Electrically-Conducting Film.—The Triplex Safety Glass Co., Ltd., King's Norton, Birmingham, are installing equipment for the production of glass coated with gold film, in sizes up to 3½ ft. by 2 ft. The gold film, which is approximately 0·0000002 in. thick, forms a conductor for an electric current for heating the glass, which will be used for aircraft windscreens, and preventing ice formation. The gold film can be coated on the inside surface of one of the two outer glasses of the complete laminated windscreen. The thickness of the coated glass can range from ¼ in. to 1 in., but the most satisfactory results were obtained with glass not exceeding ½ in. in thickness. It is expected that flat gold-film glass panels will be available for service aircraft by the beginning of 1954. By arrangement with the Plessey Co. Ltd., Ilford, Essex, complete aircraft windscreens, including the associated control equipment, will be supplied by the Triplex company.

CENTRIFUGAL-CASTING FOUNDRY, SHEFFIELD.

A foundry for producing large-diameter non-ferrous metal pipes and cylinders by centrifugal casting, at the Alsing Road Works of Millspaugh Limited, Sheffield, 9, was officially opened by the Lord Mayor of Sheffield on October 28. The foundry buildings, which are of brick and corrugated-sheet construction, consist of two bays, both 350 ft. in length; the smaller is 50 ft. and the larger 58 ft. wide. The larger bay houses four rotary oil-fired six-ton furnaces, two horizontal centrifugal casting machines, knock-out equipment, and a mould-ramming pit and drying stove; it is served by three overhead cranes, respectively, of 30, 35 and 50 tons capacity. The smaller bay houses the metal and sand stores, a small casting machine and a jobbing foundry. This bay is served by a 10-ton crane.

The sand-preparation plant in the centrifugal casting bay, which is seen towards the left in Fig. 3, on page 624, and also on the left in Fig. 4, has been constructed by Augusts Limited, and consists of a sand mill with automatic charging hopper and metering device for adding moisture. The capacity of the plant is approximately 1,000 lb., and the hourly output of the order of 5 tons. After passing through an aerator the sand is discharged into a large storage hopper fitted with a turn-table base, from which the sand is ploughed off as required. The sand is finally raised by a bucket elevator to a swivel-mounted belt conveyor which feeds it to the moulding flasks. The sand used is both new and reclaimed material. The new sand is first dried in a rotary louvre drier supplied by Dunford and Elliott (Sheffield), Limited. Reclaimed sand is conveyed from the knock-out to the sand bunkers by means of one of the overhead cranes.

The cylindrical moulding flask is fitted with a "stop-off" partitioning device, set according to the length of the casting required, and is then placed vertically on a 7-ft. diameter turn-table installed at the foot of the ramming pit, which is 20 ft. deep. The equipment is shown in Fig. 4, on page 624. The flask is secured in a truly central position by means of a spigot on the turn-table, which enters a corresponding hole in the end plate of the flask, and the whole is held true by means of the pneumatically-operated adjustable steadying arms seen in Fig. 4. A cylindrical plug or pattern, which may be of wood or metal, is lowered into the flask from a hoist fitted to the overhead crane and is held centrally in the stop-off by means of a spigot. The ramming-pit turn-table is rotated, the speed varying with the wall thickness of sand and the mould diameter. Sand is fed into the annulus between the pattern and the flask by the swivel-mounted belt conveyor briefly described above. Operators standing on a platform above the flask steady a pneumatic rammer which consolidates the sand as it passes beneath the rammer head. Sand is rammed to the top of the pattern, which is then lifted 3 or 4 in. and the process repeated until the mould is complete. The pattern is finally removed and the mould inspected and then given a black coating by means of circular brushes in the case of the smaller moulds or by hand in that of the larger moulds. In the latter case, a moulder is lowered into the mould by a hoist. The completed mould is lifted by the crane from the turn-table of the ramming pit and placed horizontally on the bogie of the adjoining mould-drying stove. This stove, seen on the right in Fig. 3, is oil-fired and operates on the re-circulation system. It has been supplied by Modern Furnaces and Stoves, Limited, Birmingham.

The metals used in the foundry are bronzes of various types and other non-ferrous alloys and the only raw materials utilised are ingots and process scrap. Swarf from the machine shop is passed through a Dunford and Elliott rotary louvre drier to which has been added a magnetic separator. The metal charge is conveyed to the furnaces by means of a Conveyancer fork-lift truck supplied by Electro-Hydraulics, Limited, Warrington. The truck is fitted with a forward-tipping lip axis discharge pan. The battery of four oil-fired tilting furnaces is shown in Fig. 1, on page 624; the furnaces are

seen with their burner assemblies open. They have been supplied by Stein and Atkinson, Limited, London, and each furnace has a nominal capacity of six tons. The linings are monolithic and to facilitate relining the furnaces may be tilted to the vertical. For charging, the furnaces are tilted to an angle of 30 deg. to the vertical and for tapping they are gradually tilted downwards. After charging, the furnaces are rotated to secure speedier melting and also, it is stated, to obtain a longer life from the lining. The products of combustion are led by downtakes into a common flue which takes them to the base of an 80-ft. high chimney. Charging and tapping are conducted from the front, or burner, end of the furnace and slagging is done from the after, or exhaust, end of the furnace. The slag is dropped into a bogie running below the furnaces. The furnaces are equipped with burners supplied by Urquhart's (1926), Limited, London, and are capable of a firing rate of 45 gallons of fuel oil per hour. Trials, however, have shown that 5 tons of gunmetal ingots can be melted in a hot furnace in 1½ hours with a firing rate of the order of 30 gallons per hour.

For the casting operation, the flask containing the dried mould is taken by a crane from the bogie of the mould-drying stove and placed upon the rollers of the appropriate horizontal centrifugal-casting machine, the two largest of which are seen under construction in Fig. 5, on page 629. When the flask is in position on the rollers, a faceplate is fitted on its open end and sealed up, and a canopy-type guard rolled into position over the machine. A funnel-like pouring basin fitted with an elongated cylindrical spout is placed in front of the casting machine and the spout introduced into the mould through an orifice in the faceplate. The machine is started up and the mould rotated at the requisite speed, whereupon hot metal is poured from a ladle through the pouring basin which enables the entry of the metal into the mould to be controlled. When the centrifugally-cast tube has cooled sufficiently the flask is removed from the rollers and conveyed by crane to the carriage of the knock-out, which consists essentially of a large fabricated framework; this is vibrated by pneumatic means. The vibrations loosen the casting from the surrounding sand. The flask is then placed against a stop on the floor and the tubular casting is pulled out by means of a wire rope over a snatch-block pulley worked by an overhead crane. The castings are normally clean when removed from the sand, but such fettling as may be required is done with pneumatic hammers and grinders.

The small jobbing foundry is equipped with three 600-lb. capacity crucible furnaces provided by James C. Waterhouse, Limited, and one 400-lb. crucible furnace supplied by the Monometer Manufacturing Company, Limited. Other equipment includes two oil-fired recirculation mould and core-drying ovens supplied by Modern Furnaces and Stoves, Limited. In the colour scheme adopted for the new foundry buildings, dark green is used for the dado, cream for the walls and roofs and French grey for the structural steelwork. Cranes are painted orange red. The various service pipes and mains are identified by contrasting colours, namely, town gas, bright yellow; fuel oil, black; compressed air, black with white bands; water pale green; electricity (alternating current), Brunswick green, (direct current), blue, and (low-voltage current for hand lamps), green with yellow bands. Every effort has been made to provide clean, well-lit and well-ventilated shops. No baths are available at present but these are envisaged as a later development. Adequate cloak-room accommodation, hot and cold water sprays and other washing facilities, however, are provided.

Many of the contractors who have supplied equipment or contributed to the construction of the new foundry have been mentioned in the text; others include Thos. Firth and John Brown, Limited, who have supplied forgings; Glenfield and Kennedy, Limited, who have produced iron castings; Jarrow Metal Industries, Limited, and the Lancashire Steel Corporation, Limited, who have furnished steel castings, and B. Thornton, Limited, who have been responsible for machine assembly and fabrication.

MINISTRY OF SUPPLY TANK FACTORY.

FIG. 1. GENERAL VIEW OF FACTORY.

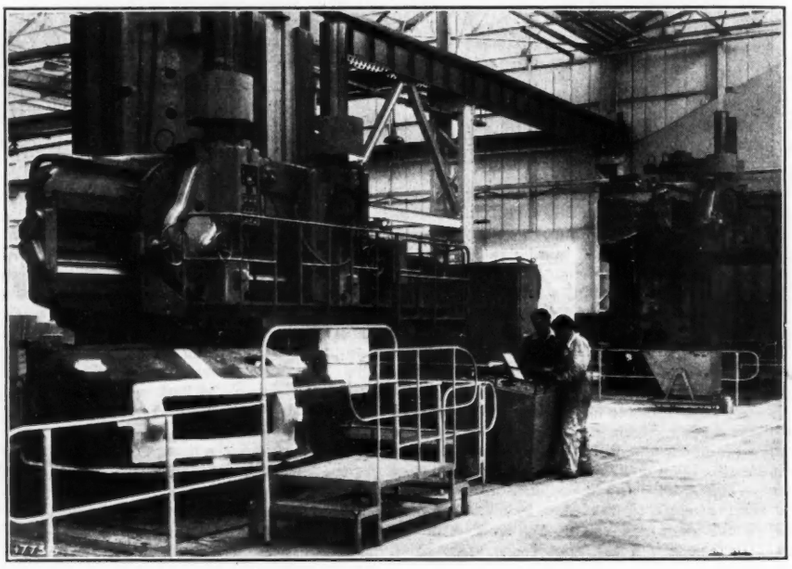

FIG. 2. TURRET CASTING IN VERTICAL BORING MACHINE.

MINISTRY OF SUPPLY TANK FACTORY.

A FACTORY for building 50-ton Centurion tanks, at Leyland, Lancashire, was opened by Mr. Duncan Sandys, the Minister of Supply, on October 23. It will be operated by Leyland Motors, Limited, whose vehicle factory is in the same area. The work of clearing the site, which is over 100 acres, commenced less than two years ago and as can be seen from Figs. 1 to 3 the buildings have been completed and many of the machines and production lines installed. Private access roads and test tracks have also been built. The general layout of the factory has been planned for modern methods of flow production on a time-cycle basis. The Mark VII Centurion, which is to be built in this factory, is the latest version of the standard tank of the British army. A brief account of the Centurion was given in ENGINEERING, vol. 150, page 325 (1950). It is driven by a 12-cylinder Rolls-Royce Meteor engine and will embody, for the first time, the unified screw thread, the standard thread agreed upon by the United States, Canada and the United Kingdom. Its main armament is a 20-pdr. gun, which is automatically held on the target by a gyro-stabiliser while the tank negotiates rough ground. During his speech, Mr. Sandys referred to a still larger and heavier support tank, not yet removed from the secret list, which will be supplied to armoured units of the British Army, in addition to the Centurion.

The main entrance of the factory, shown in Fig. 1, above, is approached by a half-mile long access road, which crosses a nearby railway line by a 60-ft. wide and 65-ft. span bridge built from pre-stressed-concrete beams. The bridge took six week-ends to complete. The factory roads, which were built as part of the site development, total two miles in length, and in addition there is a test track a mile long and 42 ft. wide, in the shape of a figure eight with a cross-over bridge at the intersection. Alongside this is a stabiliser test track 800 ft. long and 42 ft. wide and a track with a number of ramps about 1 ft. high for testing the suspension. An area paved with sets has been provided for skid turning tests. In the centre of this area there is a water trough for ford testing, the depth of which is sufficient almost to cover the hull. A railway siding of three lines and nearly 500 yards long, for which the sub-contractors were Thomas W. Ward, Limited, Albion Works, Savile-street, Sheffield, provides a connection with the main line of the British Railways. On one side of the siding there is a high-level dock and on the other the road alongside the track is at rail level. The siding will accommodate 21 rail-tankers, and header pipe connections are arranged along the track to facilitate transfer of oil to storage tanks. A gantry carrying an overhead crane for unloading ordinary railway wagons extends across the track centre. The main buildings on the site are the maintenance shop, boiler and power house, fabrication and hull assembly shop, tank assembly shop, machine shop and toolroom, and the fuel inspection shop. Besides these there is an administrative office block, a modern and well-equipped canteen, a security and welfare office, a fire station, and a swarf house. This has been designed to receive swarf from a high-level road alongside, and

MINISTRY OF SUPPLY TANK FACTORY.

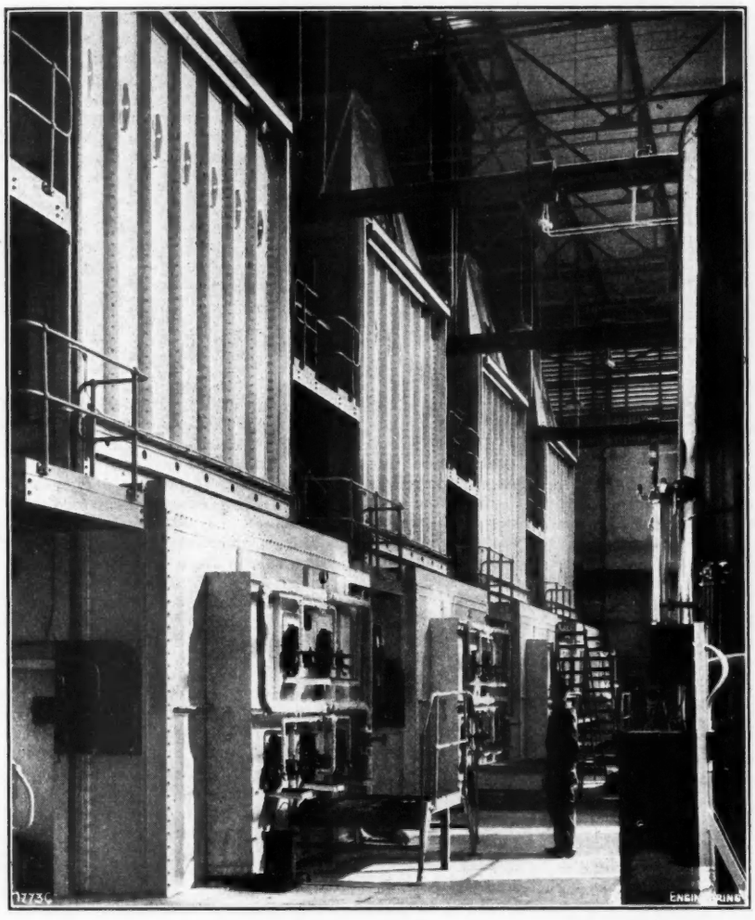

FIG. 3. LA MONT HIGH-PRESSURE HOT-WATER BOILERS FOR SPACE-HEATING AND HOT WATER.

is equipped for breaking down and separating the metal, which is then passed into hoppers for delivery to vehicles at the lower level. Lubricating and cutting oils are also processed in the same building. The architects, Harry S. Fairhurst and Son, F.R.I.B.A., 55, Brown-street, Manchester, responsible for building design and site development, worked in co-ordination with Mr. F. Grimshaw, the general works engineer of Leyland Motors, and the main building contract was carried out by A. Monk and Company, Limited, Padgate, Warrington.

The boiler house, which is shown in Fig. 3, is equipped with oil-fired boilers rated at 46,000,000 B.Th.U. per hour, supplied by La Mont Steam Generator, Limited, 83, Crawford-street, London, W.1. Pumps driven by Leyland Diesel engines circulate the hot water from the boilers through a ring-main working at 250 lb. per square inch and 350 deg. F. to unit-type heaters installed in the main bays of the factory. The oil burners, which operate on the high-pressure jet system, and fuel-oil heaters were made by Clyde Fuel Systems, Limited, Queen Elizabeth-avenue, Glasgow, S.W.2. Two vertical boilers have also been installed to provide steam when required for tracer heating of the oil pipelines, storage tanks and rail tankers. The power house is equipped with six Diesel-driven alternating-sets supplied by the English Electric Company, Limited. The engines have 16 cylinders, develop 1,600 brake horse-power at 750 r.p.m. and are supercharged by a Napier blower. Each alternator is capable of supplying 1,000 kW. The output voltage from the power house has been arranged at 3,300 volts so that it can be fed in parallel with the supply from the British Electricity Authority's grid. Two sub-stations in the factory transform the supply to 400 volts. Five air compressors, made by Alley and Maclellan, Limited, Polmadie, Glasgow, S.2, are also installed in the power house. They are driven by six-cylinder English Electric Diesel engines and supply 1,000 cub. ft. per minute at 100 lb. per square inch each. Between the power house and boiler house is a pumping room equipped with a number of sets for circulating the cooling water from the Diesel engines to the adjacent prefabricating shop for space heating. When the waste heat is not required it is dissipated through coolers on the roof above.

The fabrication shop has five bays, each 35 ft. wide and 600 ft. long. On one side of the shop the armour-plate panels that are to be used in the hull of the tank are machined and jig drilled. They then pass across the shop to the sub-assembly section and finally to the hull main-assembly section. The various assemblies are held in jigs while being welded and all joints are pre-heated by single torches using Selas gas prior to making the weld. The jigs themselves are designed so that all welds can be made in the down-hand position. For the final welding operations the hull is mounted in a manipulator, by means of which it can be rotated in two planes for ease of welding. Fume extraction equipment is installed adjacent to each manipulator. After welding, the hulls are immersed in water to test for cracks and other undesirable holes. Running the full length of the bays in the fabrication shop are combined 30-ton slow-speed and 5-ton fast overhead cranes built by Herbert Morris, Limited, Loughborough, for moving the various assemblies to their next stage. The air within this shop is changed about 15 times an hour.

From the test tank the hull is taken to the next building for machining. At present only a limited number of machines have been installed in this section. One of these, at the beginning of the line, is a large boring and facing type of machine for facing the turret ring of the stationary hull; it was supplied by the Loewy Engineering Company, Limited, 376, Strand, London, W.C.2. In the first half of the bay, along which the hull passes, all the machining operations for the engine and gearbox mounting, drilling for the turret-ring fitting and final-drive assembly are carried out. All operations are controlled by jigs to ensure that parts will be interchangeable when servicing is required. This is followed by painting; a system of forced drying is being installed. Halfway along the bay the suspension system is assembled and the tank continues its journey on a heavy conveyor belt designed by Conveyor Cafeterias Limited, 66, Wigmore-street, London, W.1.

Running parallel to the tank assembly line is the turret manufacturing section, and to one side of it is the main machine shop, which will eventually house about 1,000 machine tools. A number of large vertical boring machines have been installed for machining the turret and its components. In Fig. 2, opposite, we show one of the vertical borers, which is made by Charles Berthiez, 5, Rue Montalivet, Paris, 8; like many of the other larger machines in this shop it has remote control. The control panel, which incorporates a number of visual direction indicators to show the movement of the tool-boxes, can be seen at the right of the illustration. These controls are duplicated on panels built above the tool-boxes. It is suitable for work up to 10 ft. 6 in. in diameter and up to 15 tons in weight, and is employed for machining the fixed ring for the gun turret, which is a rolled forging.

Overhead cranes capable of lifting a complete Centurion tank run the full length of the main assembly and the adjacent hull machining bay. In the machine shop previously mentioned, the layout is arranged so that all components move along their respective machine line to completion. This main shop, which is the largest on the site, also houses the material stores, heat-treatment section, inspection and goods-inwards departments. Attached to the end of the building is the toolroom and standards room, which is fitted with Thermolux glass windows and is temperature-controlled and air-conditioned at 68 deg. F.

When the assembled tank leaves the conveyor belt it passes out to an open yard where simple running checks and turns can be made, and a concrete-surfaced ramp set at an angle of 60 deg. to the ground surface is used for testing the brake holding power. It is then taken into the final inspection, finishing and test shop, where accessories are added and final painting takes place. In this shop, correction tests and adjustment of equipment are carried out.

To show the advances made from the tank devised and built in the first World War, a small display had been arranged for the opening. The early Mark V lozenge-shaped tank of the 1914-18 war was placed at the beginning of the line of tanks on display. It weighed 29 tons, travelled at 4·6 m.p.h., and carried a crew of eight. Its armament comprised two six-pounder guns and four machine guns and the armour was 6 and 14 mm. thick. The engine was a 150-h.p. Ricardo unit. At the other end of the display was the Centurion, which carries four men, travels at 22 m.p.h. and mounts a 20-pounder gun. Between these two, in advancing order, were the Vickers medium, the 6B light tank, the Matilda, Crusader, Cromwell and Comet.

NEW FACTORY FOR DE HAVILLAND PROPELLERS LIMITED.—Hollow steel-blade propellers for aircraft are to be manufactured in a new factory at Edmonton, Middlesex, acquired recently by de Havilland Propellers Ltd., Hatfield, Hertfordshire. Work will commence in December, and by Easter, 1954, it is expected that about 150 people, mostly skilled machinists, will be employed at Edmonton. The first steel blades from the new factory are destined for the Bristol Britannia air liners powered by four Bristol Proteus 3,350-h.p. propeller turbines. A second production line will be established for the Blackburn Beverley military transport aircraft with British Centaurus 173 engines. Hollow steel propellers are now made for turbine shaft outputs up to 9,000 brake horse-power.

LUBRICATION OF GEARS.

At a meeting of the British Gear Manufacturers Association held on November 3 at the Piccadilly Hotel, London, a paper on "Gear Lubrication" was presented by Mr. N. Blamforth, of the Vacuum Oil Company, Limited. The aim of all lubrication, he said, was to maintain a film between the rubbing surfaces and so avoid metal-to-metal contact. The chief factor in maintaining such a film was the viscosity of the oil, but as this was reduced with temperature rise, various substances were added to oils which would give separating films for gears running at higher temperatures. Among the substances which Mr. Balmforth mentioned were: phosphorus, which formed a thin phosphate film on the metal; metallic soaps, particularly lead soap, a film of which was capable of withstanding heavy loadings; and sulphur or chlorine products which reacted at elevated temperatures with the metal surface to form sulphide or chloride films of high strength. Being corrosive, however, they should not be used with non-ferrous materials. The stability of the lubricant was also important, especially in circulatory systems; breakdown of the oil could cause sludging and consequent blockage of pipes.

The rolling contact of spur and helical gears tended to assist in film formation due to the wedge action, but in worm and hypoid gears, where there was a large degree of sliding, the film was not easily formed. As a general rule, at high speeds, more oil was drawn between the surfaces and a lighter oil could be used. Figures quoted by the author for worm gears ranged from a viscosity of 910 Redwood No. 1 at 100 deg. C. for 200 ft. per minute peripheral speed to 290 for 2,000 ft. per minute. He emphasised the advantages of running-in for gears and urged that manufacturers should make a point of this when supplying equipment. In regard to methods of lubrication, Mr. Balmforth thought that a speed of 3,000 ft. per minute was the maximum peripheral speed for splash lubrication, as above this the teeth cut a channel in the oil. For higher speeds, sprays should be used, and this raised the question of which side they should feed. Ideally, it would seem they should be on both sides, but this was not economic. He considered that it made very little difference ultimately which side was chosen, but it was important to spread the oil over the mating surfaces. Temperature rise of the oil was normally limited to about 30 deg. F. and this necessitated an adequate sump. A circulation time of 20 minutes was his recommendation for the flow rate of the oil. The sump should also have proper drainage for removal of sludge and water and the suction pipe should be placed so as to avoid any danger of water intake. An important point where heaters were fitted was that their surface temperature should never be so high as to cause carbonisation of the oil. Also it was advantageous in coolers to keep the oil pressure higher than that of the water, so that the risk of water contamination would be reduced. Pitting on the contact line was probably due to high local stresses and might settle down after a time. Smooth abrasion was polishing due to lubrication failure and caused scuffing of the surface. The next step was ridging, where metal was ground away on either side of the pitch line and the gear had then definitely failed. The remedy for this was an oil with a higher film strength.

In the discussion which followed, emphasis was again laid on the need for running-in; it was also suggested that manufacturers should always state what grades of oil were suitable, and how often the oil should be changed. In answer to a question, Mr. Balmforth said that if smooth abrasion occurred it was customary to recommend using the next heavier grade of oil. He also said that the film thickness of a medium turbine oil was about 100 microns. Asked whether the surface finish affected the adhesion of an additive oil film, Mr. Balmforth pointed out that the bond was a chemical one, and so largely unaffected by the finish. The film was a very thin one and formed more readily at higher temperatures; a lead-soap compound was being developed which was giving oils with a film strength approaching that obtained with sulphur and chlorine additives, and, of course, without their corrosive properties.

LABOUR NOTES.

In spite of token strikes and other forms of pressure brought to bear upon them, the representatives of the Engineering and Allied Employers' National Federation firmly rejected, for a second time, the claim of the Confederation of Shipbuilding and Engineering Unions for a wage increase of 15 per cent. for all adult male employees in engineering and associated industries, at a meeting in London on November 5. The claim was originally refused by the employers on October 7, but the trade-union leaders had a further meeting with representatives of the Federation on October 29, when additional statistics in support of the claim were put forward. The Federation officials asked for a little time to consider these new arguments but warned the trade-union leaders that a preliminary examination of the statistics then submitted had shown nothing which would justify any increase in wages beyond that conceded in November last year.

A statement issued by the Engineering and Allied Employers' National Federation, after the meeting on November 5, announced that the employers had shown the leaders of the Confederation that the earnings of men engaged in the engineering industry had more than kept place with the rise in the cost of living, and that any further increase in wages must result in an advance in the prices of engineering products. They stressed the impossibility of advancing such prices in the face of strong and growing foreign competition, especially in overseas markets, and regretted their inability to concede any increase in wages. Such a course would result in a continuous loss of orders with consequent bad effects on employment. During the negotiations Sir Percy Mills, Bt., the President of the Federation, called attention to the "sporadic stoppages of work which were occurring up and down the country" and expressed the hope that better counsels would prevail.

It was stated subsequently that the executive council of the Confederation of Shipbuilding and Engineering Unions would meet at York yesterday to consider the rejection of the claim and possibly to make recommendations. These will be discussed at a special meeting of delegates from the 39 unions affiliated to the Confederation at a meeting in London on November 19, at which decisions will be made on the course to be pursued. The three alternatives appear to be a ballot as to whether strike action shall be taken, the presentation to the employers of a smaller claim, or an approach to the Ministry of Labour for their intervention, with a view to the submission of the claim to arbitration.

Operatives at engineering factories in the London and home-counties area ceased work on November 5 in protest at the former rejection of their wage claim, and some of these men joined in demonstrations outside the Federation's offices while the second series of negotiations were in progress. Employees at other engineering factories in the area staged token strikes of an hour or two's duration. In all cases, however, only comparatively small numbers of men were involved. Token strikes which lasted half-a-day took place at certain establishments in the Sheffield area on November 2. A mass meeting took place in the town later in the day at which a resolution was passed demanding a 24-hour stoppage of work if the wage demand were again rejected.

Wage claims in sections of the metals and engineering industries other than those covered by the Confederation's demand for a 15 per cent. increase are also receiving attention, according to a statement in the November issue of the *Transport and General Workers' Record*, the official journal of the Transport and General Workers' Union. In this connection, however, the union warns its members that it is not able to report any variation in the general attitude of employers to wage claims. On the contrary, a continuing resistance is to be expected. This will necessitate, the union affirms, that it shall exercise to the full that sense of responsibility which its members are entitled to expect in matters affecting their livelihood.

The T.G.W.U. reports that employers in the foundry industry are prepared to conclude an agreement giving operatives in the industry facilities for purchasing safety boots at cost price. This is in addition to their recommending the introduction of a regulation providing for the protection of employees' legs and feet by means of leggings and spats, to be issued at the employers' cost.

Claims for a substantial increase in wage rates were presented by the unions catering for the Merchant Navy on November 5 and are expected to be discussed at a meeting of the National Maritime Board during the coming week. The present indications are that the general principle and implications of the claim will be considered at a meeting of the Board as a whole, and that this will be followed by sectional negotiations on the rates of pay for the different grades of officers and seamen. In all, about 140,000 engineering, navigating and radio officers and men are involved in the new demands. It may be recalled that the last increase granted to seafarers came into force in January, 1952, when ratings in ships where food was supplied by the owners, received an increase of 2*l.* a month. This brought the minimum rate for ordinary merchant seamen to 15*l.* a month, with food provided. Senior officers in the larger ocean-going vessels received additional pay amounting to 4*l.* 5*s.* a month. Officers in smaller ships, and junior officers, received increases in proportion.

Motions intended to raise the retiring age of all teaching and administrative staffs at the University of Oxford to 67 were approved by the Congregation of the University on November 3. It was stated by the senior proctor that the rules then approved would have a much wider application than had been originally intended, because, when proposals for raising the retiring-age limit were first introduced, there had been a distinction between persons employed in an administrative capacity and those engaged in teaching and research work. Although this differentiation had been removed, however, there would remain a small number of University officials for whom a retiring age of 65 would remain compulsory. It was hoped to introduce amending legislation for the removal of this anomaly at an early date.

Somewhat diverse views were put forward when the question of the retiring ages of University officers was debated at a meeting of the Senate of the University of Cambridge on the same day. The matter had been referred to the Senate by the Council of the University in a brief report, in which the Council contented themselves with asking for the Senate's opinions without giving any guidance as to their own views. One speaker considered that it would not be to the good of the University to retain lecturers in their teaching posts for a longer period, and that a special disadvantage of such a course would be the excess of competition which would arise among the younger graduates for the reduced number of vacancies open to them.

On the other hand, the view was expressed that there were obvious advantages in retaining for a further two years the more outstanding teachers of the various faculties, and that these more than compensated for the risk of prolonging the working life of less efficient lecturers. Another member of the Senate felt that there should be greater facilities for making use of the services of retired officers of the University. Other views put forward were that many faculties suffered heavily through losing some of their best men at the age of 65, that increased use should be made of retired lecturers, and that some of the abler teachers tended to transfer their services to industry, owing to the existing retiring age of 65 and the inadequate pension prospects which accompanied it.

REFUSE DISPOSAL PLANT AT SHEFFIELD.

HEENAN AND FROUDE LTD., WORCESTER.

FIG. 1. TIPPING HOUSE.

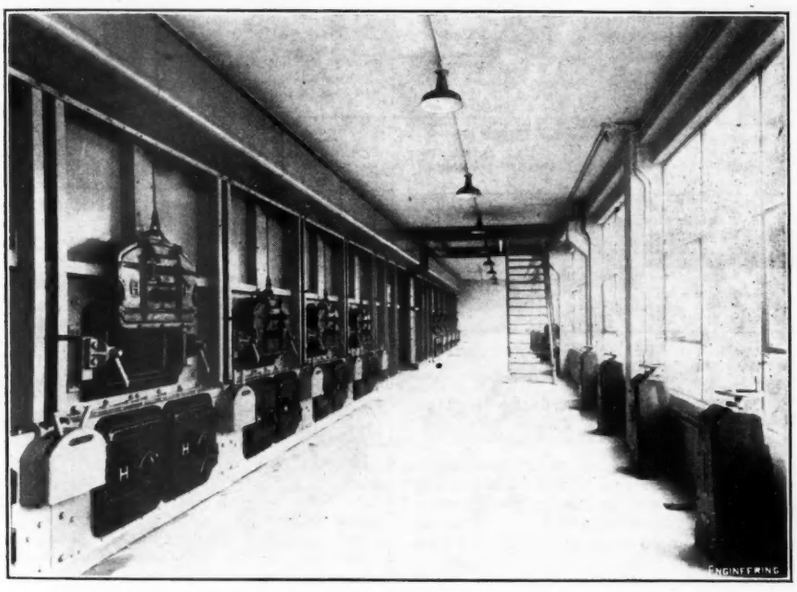

FIG. 2. INCINERATORS.

REFUSE DISPOSAL PLANT AT SHEFFIELD.

A NEW refuse-disposal plant has recently been put into operation by the Sheffield City Council, capable of dealing with 260 tons of crude refuse per eight-hour working day, which is equivalent to half the total weight of refuse produced in the city, the population of which is 513,700. The main contractors for the new plant, which is built on the site of a 12-cell two-unit incinerator erected in 1901 at Penistone-road, Sheffield, are Messrs. Heenan and Froude, Limited, Worcester. The layout was planned around the inclined roadway and buildings which housed the old destructor, the main building, provided with a new roof, being used as the refuse-reception house, leaving the ground floor available for storage, baling and other purposes. It has thus been possible to avoid the need for deep pits below ground level. It is expected that about 2,000 tons of scrap metal will be recovered per year, and 11,000 tons of cinders which can be used as fuel for steam-raising at the public baths and wash-houses or for hot-house heating.

To ensure flexibility of operation, and to provide continuous operation in emergencies, twin units are employed throughout the plant. Incoming refuse vehicles, after weighing, pass up an inclined roadway into the tipping house, which is illustrated in Fig. 1, where they deposit their loads into either of two reception hoppers, each of which has a capacity of 120 cub. yards (about 40-50 tons) and is equipped with a feed-regulating mechanism. Each hopper discharges on to a 9-ft. wide plate-feed conveyor which can be operated at two speeds, to suit the type of refuse being handled.

Two pairs of wide troughed elevating-belt conveyors, totally enclosed in the building, deliver the refuse from the feeders to primary screens. Gangways give access to the conveyors at any point, and two-way chutes are provided so that either of the first two elevating conveyors may discharge to either of the second pair. In the two primary screens, which are of the horizontal revolving-barrel type of large diameter, the refuse is propelled over the mesh-plates by an internal helix. Preliminary separation of dust takes place in the first section of mesh; the dust is discharged to a belt conveyor. In the second section of mesh, oversize material is extracted for treatment in the secondary screens. The tailings rejected by the screen are fed on to picking-belt conveyors. Both the primary and secondary screens are totally enclosed and are friction-driven by their supporting rollers, which are fitted with roller bearings and rubber tyres to ensure smooth quiet running.

The secondary screens are of similar construction to the primary screens, but are slightly smaller. The remaining dust is extracted and fed to the belt conveyor in the first section of the mesh; the adjacent mesh removes crude cinders and passes them to Heenan garbage separators arranged in two pairs below the screens. These separators remove a large proportion of the dross, vegetable and other matter, and the cleaned cinders are collected on to a belt conveyor. The secondary tailings and the debris from the garbage separators are discharged on to the picking belt conveyors for eventual transfer to the incinerator.

The dust and cinder conveyors, enclosed in a single gantry with a central access gangway, elevate the materials to reinforced-concrete hoppers, the dust section of which has a capacity of 60 tons and the cinders portion a capacity of 30 tons. The hoppers are fitted with quick-acting roller doors for rapid gravity discharge to vehicles standing beneath. Magnetic pulleys extract ferrous metals from the cinders and the dust. It is possible to by-pass the entire screening process by the use of chutes which divert the crude refuse from the head of the second pair of elevators directly to the picking conveyors.

The tailings are conveyed by the two slowly-moving picking belt conveyors into the salvage room. In this room, men stationed beside the belts recover articles worthy of salvaging and throw them into chutes leading to storage bins on the floor below. A hoist is provided for handling bottles and other materials unsuitable for depositing in the chutes. Above each picking conveyor an electro-magnetic overhead separator, supplied by Rapid Magnetic Machines Limited, Birmingham, extracts tins and ferrous metals, which are conveyed by a chute to the lower floor. On this floor, two mechanically-operated triple-ram Heenan scrap-metal balers, of the all-geared type, are provided; these machines are capable of producing 70 lb. to 75 lb. bales measuring 18 in. by 12 in. by 6 in. to 9 in. They can deal with the whole of the recovered tins during the working shift. Provision has also been made for installing Heenan One-Fill vertical power-operated paper balers in an enclosure on the lower floor to which paper-delivery chutes lead from the salvage room. A runway system is provided in the baling room for handling bales of metal, paper and textiles.

The materials still remaining on the picking conveyor are delivered by a pair of troughed elevating belt conveyors to a central point in the incinerator house, from where they are discharged by cross-over chutes to either of two distributing belts above two incinerator units. Each distributing conveyor has a travelling tripper so that the tailings may be discharged directly to the top feed openings in the incinerator, or on to a storage floor for hand-feeding to the furnaces. Each tripper serves any desired cell of a five-cell unit.

The incinerators, illustrated in Fig. 2, are of the Heenan steel-cased mechanical type with hydraulically-operated grates. Each unit comprises five cells with combustion chambers and a special arrangement for burning dead carcasses. They are installed at first-floor level, thus facilitating the discharge quenching and handling of the clinker. Each of the ten grates is supported on a carriage which is withdrawn hydraulically when clinkering is necessary, the clinker being scraped off by the deadplate under which the moving grate passes. The clinker falls down a cast-iron chute to an enclosed chamber—one for each grate—at ground level, incorporating a stillage system of clinker skips so that the falling clinker is caught and stored in a position convenient for quenching by high-pressure water jets pumped from the River Loxley. Subsequently, the clinker is removed to the clinker yard; ultimately a clinker-handling plant is envisaged. The clinker skips are transported and tipped by a battery-operated truck.

To deal with bulky combustible material such as old furniture, bedding, etc., one of the furnaces is provided with a large mechanically-operated charging door.

The hydraulic system for operating the grates, supplied by Messrs. Fielding and Platt, Limited,

SAFETY MECHANISM FOR OIL BURNERS.

BRITISH COMBUSTION EQUIPMENT, LIMITED, POOLE.

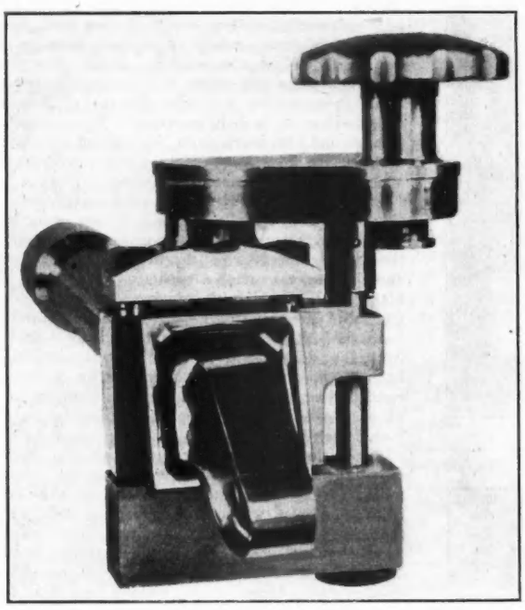

FIG. 1. BURNER WITH SPRAYER HEAD IN POSITION.

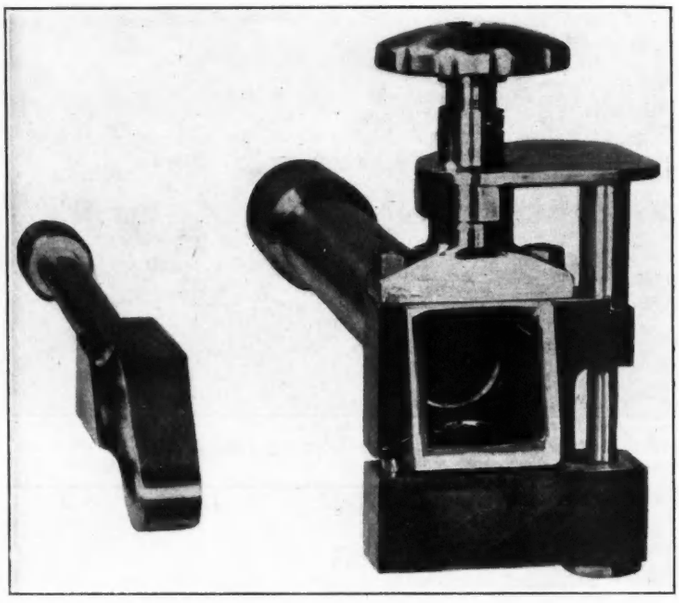

FIG. 2. BURNER WITH SPRAYER HEAD REMOVED.

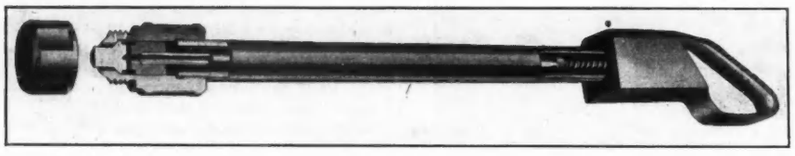

FIG. 3. SECTIONED SPRAYER HEAD WITH ATOMISER REMOVED.

Gloucester, comprises duplicate high-pressure pumps and an accumulator coupled through control valves to actuating cylinders. The control valves, which are interlocked with the control of the quenching water and the quenching-chamber doors, are operated from the front of the furnaces. The quenching chambers and furnace casings are ventilated and cooled by a system of ducts connected to the intake of the forced-draught fans. The furnace castings are cooled by air tapped from the pressure of the forced draught. The gases leaving the incinerator pass through a flue system to a water-type dust catcher and thence to the chimney.

The foundations and new buildings were constructed by Messrs. George Longden and Son, Limited, Sheffield, under the supervision of the city architect. The new buildings, comprising the screen house, picking and salvage rooms, and the incinerator house, consist of concrete framing and 9-in. red-brick side filling, with continuous side glazing and reinforced-concrete barrel-vault roofs designed by Twisteel Reinforcement Company, Limited, 43, Upper Grosvenor-street, London, W.1. With this type of roof structure, the tendency for dust to collect on internal structural work is greatly reduced. The absence of exposed steelwork also reduces corrosion and maintenance costs to a minimum.

To improve the conditions for personnel working in the plant, a comprehensive dust extraction plant has been supplied by Messrs. Newton Collins, Limited, Birmingham, in the handling, screening and salvage sections. Twin units handle dust arising from the refuse reception hoppers, and two further units dispose of the dust collected from the screen-house and picking-room. Electrical power is furnished through a transformer station built into the basement of the tipping house and is fed to local distribution boards in each of the main sections of the plant.

SAFETY MECHANISM FOR OIL BURNERS.

In pressure-jet oil-firing equipment operating on heavy fuel oil it is essential to prevent fuel at high pressure from leaking or discharging into the stoke-hold when the sprayers are withdrawn. It is also important that, in the event of the atomiser parts or the burner tip being carelessly or incorrectly assembled, large quantities of un-atomised fuel oil should not be discharged into the combustion chamber. Two mechanisms designed to cover these two safety considerations are now incorporated in the oil burners manufactured by British Combustion Equipment, Limited, Poole, Dorset.

Figs. 1 and 2 show an arrangement whereby the sprayer cannot be withdrawn from the burner unless the oil supply is shut off. The sprayer head is shown in Fig. 1 secured in the housing by a pinching screw, which at the same time makes a metal-to-metal ball joint for the oil supply. The pinching screw has a slightly tapering square-section upper end which engages freely with the handwheel only when the oil supply is shut off. The handwheel is loosely mounted in a quadrant crank which effectively shrouds the top of the pinching screw, preventing the application of a spanner or any external appliance to release the sprayer. The quadrant crank itself operates the spindle of a single-port shut-off cock in the lower steel forging. The latter embodies the male portion of the ball joint (Fig. 2).

In order to operate the pinching screw, the quadrant crank has to be rotated so that the handwheel is located over the pinching screw, as in Fig. 2. This movement closes the shut-off cock. Rotation of the pinching screw causes the shut-off cock housing, with the oil-supply ball joint, to move up or down relative to the sprayer housing. Thus, when the handle is turned to release the sprayer the ball joint retracts, leaving the sprayer free to be withdrawn. At the same time, an interlock on the shut-off cock spindle engages with a stop on the sprayer housing, so that it is impossible to move the quadrant and open the cock while the sprayer is withdrawn. Since the ball joint is retracted, damage of the ball-joint face from careless handling of the sprayer in and out of the housing is impossible. When the sprayer head is replaced and located in its housing, and the handwheel is rotated to secure it in place with the oil-joint faces tightened together, the resulting disengagement of the interlock allows the handwheel to be lifted from the square end of the pinching screw and the quadrant crank to be turned to open the oil cock. Sprayers can be changed in less than 30 seconds.

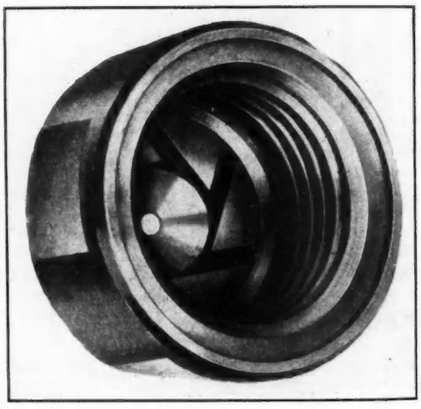

FIG. 4. ATOMISER.

In Fig. 3 is shown the means by which fuel is shut off at the sprayer in the event of the atomiser—illustrated separately in Fig. 4—being removed or improperly assembled. At the end of the sprayer body is a spring-loaded cylindrical seal which forms the inner closure of the atomiser whirl chamber when the atomiser is correctly assembled on the sprayer. Should the sprayer be removed, a mitred valve face on the cylindrical seal is forced by the spring to seat on an internal face in the sprayer body, making a fuel-tight joint. Free passage for the fuel to the orifice is obtained only when the atomiser is screwed into place.

TITANIUM—A METAL OF ENGINEERING IMPORTANCE ?*

By P. L. TEED, A.R.S.M., M.I.M.M., F.R.Ae.S., F.I.M.

(*Concluded from page* 605.)

ENGINEERING FEATURES OF TITANIUM AND ITS ALLOYS.

WHAT has already been said amounts, at best, to no more than a sketch. Its deficiency in detail has a twofold origin—lack of essential knowledge and the necessity for brevity in the presentation of such as does, in fact, exist. The former, of course, springs from the strange history of the metal. Neglected alike by chemists, engineers and physicists for well over a century and a half, it has during the last decade, and in particular during the last four years, been the subject, on an international scale, of fevered and intensive researches, the publication of the results of which has often been forbidden on the more than doubtful ground of national security.

As an introduction to the final section of this paper, which is intended to supply the answer to the question contained in its title, it is proposed to give a brief summary of what has gone before.

(1) Titanium and its alloys, compared with most other engineering materials, are extremely costly.

(2) The mechanical properties of commercially-pure titanium are comparable with those of mild steel, except as regards its Young's Modulus. This is about half that of ferritic materials and one and a half times that of aluminium and its alloys.

(3) The mechanical properties of titanium alloys, excluding their Young's Moduli (15 to 18 $\times$ 10^6 lb. per square inch), are, at room temperature, comparable with those of most alloy steels.

(4) The specific gravities of the titanium alloys being about 4·3 to 4·7 their room temperature specific mechanical properties, other than elastic moduli, are very high.

(5) Titanium alloys, like those of other metals, are heat sensitive. Above 100 deg. C. they have better specific mechanical properties than the wrought-aluminium alloys under comparable conditions, but at temperatures in excess of 400 deg. C. those of several ferrous and non-ferrous alloys are superior to the best of the titanium alloys. Above 800 deg. C., nitrogen, oxygen, steam, carbon monoxide, and carbon dioxide react somewhat vigorously with the hot metal.

(6) Titanium and its alloys have high melting points as compared with alloy steels.

(7) The workability of titanium and its alloys presents considerable difficulties. Castings for most purposes cannot be made. Forging is more costly than that of alloy steels. Welding calls for special techniques. Machining is somewhat more difficult than that of austenitic steel. Cold reduction necessitates new or modified methods.

(8) Titanium and its alloys are resistant to many forms of chemical attack. In particular they have a singularly good resistance to seawater, even when this is hot.

(9) The rubbing properties of titanium and its alloys are poor. They possess a marked tendency to pick-up on themselves and on other metals.

CIVIL-AIRCRAFT COSTS.

The foregoing, in which both the high cost of the metal and its alloys and the many difficulties associated with their fabrication have, it is hoped, been given the right emphasis, may have quenched any enthusiasm which the chemical, mechanical and physical qualities of the metal may have engendered. It would surely seem that where weight is not an important consideration, titanium and its alloys, at their present impressively high prices, will have few applications, unless the chemical characteristics of the metal are such as to outweigh what can otherwise only be regarded as their economic unattractiveness. On the other hand, where weight is of the utmost importance, as in transportation and in particular in air transportation, the case for the use of this most expensive metal may not be wholly illusory. To put this matter realistically, some examination of what is currently paid for civil aircraft is worthy of consideration. In Table VI the approximate cost per lb. of a number of civil aircraft on the basis of their empty or basic-equipped weight is set out.

Persons without aeronautical experience may well be surprised at what is paid for aeroplanes on the basis selected. Even the writer, deeply involved as he is, feels concern. He, however, realises that such prices are at present inevitable, owing to the combined influence of the cost of research and design and the limited number of aircraft which are built on the basis of any one design. While Table VI may be interesting and may serve as an introduction to a study of the relationship of aircraft costs and those of the materials in them, Table VII is far more realistic. It sets out what is paid per lb. of disposable load, which can, of course, be used in the form of fuel, freight and/or passengers. The figures in the table, of course, provide no measure of the respective economic merit of the different aircraft, for no allowance is made for their relative speeds.

TABLE VI.—*Approximate Cost Per Lb. Weight of Civil Aircraft.*

Aircraft.	Cost in Pounds Sterling Per Pound of Basic Equipped Weight.*
Viscount 700	6·8
D.C. 6A	7·1
Super-Constellation	7·7
Britannia	7·9
Convair 340	8·5
Comet I	8·8

* Basic Equipped Weight is the weight of the aircraft with fixed and removable equipment installed to enable it to perform a given role. It includes airframe, power plants, accessories, trapped fuel and oil, and all other fluid systems (hydraulics, coolant, water injection, de-icing and anti-icing) filled to capacity, but without fuel, oil and water for use of crew and passengers.

TABLE VII.—*Approximate Cost Per Lb. of Disposable Load.*

Aircraft.	Cost in Pounds Sterling Per Pound of Disposable Load.*
D.C. 6A	6·4
Super-Constellation	7·8
Britannia	8·0
Convair 340	8·5
Viscount 700	9·2

* Disposable Load includes crew, passengers, parachutes, baggage, cargo, personal safety equipment and expendable items, such as fuel, oil, ammunition, rockets and bombs.

TABLE VIII.—*Approximate Weight of Basic Equipped Weight Required to Carry One Pound of Disposable Weight.*

Aircraft.	Approximate Basic Weight in Pounds Required to Carry One Pound of Disposable Weight.
D.C. 6A	0·92 lb.
Britannia	1·01 lb.
Super-Constellation	1·13 lb.
Viscount 700	1·35 lb.
Convair 340	1·90 lb.

The figures in the table, of course, provide no measure of the respective economic merit of the different aircraft, for no allowance is made for their relative speeds.

It is axiomatic that disposable load is the Mecca of every aircraft designer. It will be equally appreciated that this can only be reached by the use of appropriate materials in the form of airframe, engines, etc. Further, since disposable load is derived only from engine power, one of many potent factors will be the ratio of the weight of engines required to produce a certain thrust as compared with the weight of airframe necessary to carry the power plant. Table VIII will, it is hoped, put this difficult matter in realisable terms by using certain contemporary aircraft, designed for different purposes and flying at different speeds, as an example of what the author wishes to convey.

The cost per pound of basic-equipped weight and the amount of this basic-equipped weight required to carry one pound of disposable load have been disclosed. It remains to show what gross revenue can be earned per unit of disposable load. Due to the courtesy of Mr. Peter Masefield, Chief Executive of British European Airways, the gross earnings per pound of disposable load of certain civil aircraft are set out in Table IX. This table deals with the revenue earned per annum per pound weight of disposable load available in what might be called inter-city aircraft. The author is indebted to the staff of the British Overseas Airways Corporation for comparable figures, though not assessed on quite the same basis, for inter-Continental aircraft. The figures are given in Table X. They have been prepared on the assumption that the machines have an annual utilisation of 3,000 hours. Probably the revenue earning life of both classes of aircraft, particularly as regards the newer types, will be 8 to 10 years.

TABLE IX.—*Gross Revenue Per Annum Per Pound Weight of Disposable Load, 1952-53.*

Aircraft.	Gross Revenue in Pounds Sterling Per Pound of Disposable Load.
Pionair	15*l.*
Elizabethan	15*l.*
Viking	22*l.* 10*s.*
Viscount	35*l.* (estimated)

TABLE X.—*Gross Revenue Per Annum Per Pound of Pay-load.*

Type of Aircraft. Block Speed 225 m.p.h.	Gross Revenue Per Annum Per Pound of Pay-load.
Freight	27*l.*
Standard passenger	56*l.*
Tourist	39*l.*
Propeller Turbine. Block Speed 275-300 m.p.h. :	
Freight	33*l.* (estimated)
Standard passenger	68*l.* (estimated)
Tourist	48*l.* (estimated)
Jet. Block Speed 350-400 m.p.h. :	
Freight	42*l.* (estimated)
Standard passenger	87*l.* (estimated)
Tourist	Not estimated

TABLE XI.—*Approximate Cost of Civil Aircraft Per Pound Weight of Pay-load.*

Aircraft.	Cost in Pounds Sterling Per Lb. Weight of Pay-load.
D.C. 6A	11·6*l.*
Britannia	12·8*l.*
Viscount 700	16·1*l.*
Super-Constellation	18·2*l.*
Convair	21·5*l.*
Comet I	33·3*l.*

Finally, while thinking from various points of view of the price of a commercial aeroplane, it is not inappropriate to consider the cost of a unit of pay-load in various civil aircraft designed for flight at different speeds over routes necessitating different lengths of flight between stops (which may be determined either by the position of cities or by the necessity for refuelling) are set out in Table XI. The figures suggest that if pay-load can be increased by use of titanium and/or its alloys, even at their present price, their use may be economically justifiable. This question requires to be examined from more than one point of view.

POSSIBLE USE OF TITANIUM AND/OR ITS ALLOYS IN AIRCRAFT.

Airframe Applications.—There would appear to be two cases in which the use of commercially-pure titanium in the airframe would be likely to reduce its weight. In one instance the advantage to be derived from the use of the new metal arises, not from its specific mechanical properties, but from its possession of two notable characteristics, high melting point and low specific gravity. In all aircraft, whether piston-engine or gas-turbine propelled, fireproof bulkheads are used between the power plant and the surrounding structure. For many years it has been the universal custom to employ an austenitic steel of the 18 : 8 type for this purpose. Now, it is technically perfectly feasible to use commercially-pure titanium of the same thickness. This, of course, leads to a saving in weight in the ratio of the specific gravity of titanium to that of the 18 : 8 alloy—roughly the weight of the parts envisaged is reduced to 57 per cent. of their steel

* Paper read before Section G of the British Association at Liverpool, on Tuesday, September 8, 1953. Abridged

ones—this saving, in a large four-jet civil or military aircraft, may well amount to 100 lb. per machine.

A second application of titanium which can be advantageously made is the jet pipe shroud, also normally made of austenitic steel. This shroud has a three-fold function—it provides an annulus around the jet pipe through which cooling air passes, reducing the temperature of the jet pipe and also that of the surrounding aircraft structure. Further, should the jet pipe develop a hole, the shroud will, for some time, prevent the hot gases from impinging on the structure. In such a four-engine machine as has been envisaged, the use of titanium jet-pipe shrouds instead of austenitic steel ones of the same thickness, will lead to a reduction in weight of about 200 lb.

Whether or not other aircraft parts could be made of titanium alloys giving rise to increase in pay-load, depends on the relative structural efficiency of the materials employed. Unfortunately, there is no agreed measure of material structural efficiency. That quoted, however, in a recent paper[6] is, in spite of its manifest deficiencies, often employed. Depending on the purpose of the application—tensile strength, stiffness, in the form of a beam, Euler strut or of a panel loaded in compression, the author of the paper to which reference is made determines the merit of a material for the purpose in view by the magnitude of the figure obtained by dividing the physical property which constitutes the design criterion by its specific gravity. One of his tables is reproduced in Table XII. If this method of determining the engineering value of structural materials were sound, then clearly tension members would be made of titanium alloy and panels loaded in compression of a magnesium-zirconium one, while Euler struts could be made of any material. Even when lightness is the primary desire, there are other relevant considerations incapable of evaluation on the basis of an all too simple formula. To mention but a few of the qualities incapable of numerical evaluation which the engineer has to consider, there are such matters as availability, workability, "joinability," notch sensitivity under static, impact and cyclic stresses, etc. Finally to get away from a theoretical approach to what is in fact a practical survey, Table XIII sets out the materials of which the airframes of two large aircraft (both being in production in this country at the present time) are being made. They have been designed by two entirely different design staffs between whom no liaison exists, yet there is some similarity, both in the materials and in the relative quantities employed in the two cases.

The author having demonstrated that there is no method of determining whether or not titanium alloys can be advantageously employed in the structure of airframes, save the most convincing one of all, experiment—sums up his views as to the possibility of using such alloys in airframes. For fireproof bulkheads and jet-pipe shrouds, commercially-pure titanium can definitely be advantageously employed, but whether the alloys can be used in the structure of airframes and undercarriage cannot be ascertained except by protracted and realistic trials. The fact that the strong wrought-aluminium alloys have not always proved themselves satisfactory in the form of forgings, due largely to their very varying directional mechanical properties, suggests that here is a field in which the titanium alloys should most certainly be given a trial. Their higher specific strength, of course, raises expectations of weight economy. On the other hand, the room-temperature lattice of titanium being hexagonal, the fear is raised that directionality will not be absent—theory can provide no satisfactory answer, but experiment can give convincing proof. Finally, another suggestion is that as in an aircraft there are certain moving surfaces which have to be mass-balanced, if it were possible to decrease the structural weight of these parts by employing titanium alloys, a reduction in excess of this saving would be obtained because the balance weight would similarly be less.

Aircraft Gas-Turbine Engines.—In an earlier study by the present author,[7] it was indicated that trials of titanium and titanium alloys as the material for components of gas turbines had received considerable attention. A table there noted, derived from Hanink, is now reproduced as Table XIV. It shows at the then prevailing prices for titanium alloys (which were substantially the same as those existing to-day), what was the actual cost of saving weight. A later and more comprehensive study by a British company making jet engines has shown that by the most extensive use of titanium, the estimated cost of weight saved would be 59*l.* per pound.

Table XIV considered in conjunction with Tables VII, VIII and IX has great value. It shows what a very experienced gas-turbine engineer has been able to accomplish by the use of titanium alloy. The experiment involved both re-design and fabrication. Were this trial to be repeated in its entirety, the same result would not necessarily be obtained.

TABLE XII.—Relative Merit for Structural Purposes of Aircraft Alloys.

—	Specific Gravity.	Design Tensile, Lb. Per Sq. In.	Young's Modulus, Lb. Per Sq. In.	Specific Strength, Lb. Per Sq. In.	Specific Stiffness, Lb. Per Sq. In.	$\sqrt[3]{E}/S.G.$
Aluminium alloy	2·9	68,000	$10{\cdot}5 \times 10^6$	23,700	$3{\cdot}66 \times 10^6$	76·3
Magnesium-Zirconium alloy ..	1·8	40,000	$6{\cdot}3 \times 10^6$	22,200	$3{\cdot}50 \times 10^6$	102·6
Alloy steel	7·9	100,800	$28{\cdot}0 \times 10^6$	12,800	$3{\cdot}57 \times 10^6$	38·7
Titanium alloy	4·4	190,000	$15{\cdot}5 \times 10^6$	42,500	$3{\cdot}52 \times 10^6$	56·7

TABLE XIII.—*Materials for the Airframes of Two Large Contemporary Aircraft.*

(Basic equipped weight of each about 70,000 lb.)

Material and Form.	Weight as Percentage of Total Structure Weight.	
	Aircraft A.	Aircraft B.
Aluminium Alloys:		
Sheet and strip ..	44·0	58·7
Bars and sections ..	28·0	18·3
Tubes	2·0	1·4
Castings and forgings ..	2·0	2·4
	76·0	80·8
Ferrous Alloys:		
All forms	8·0	17·0
Magnesium Alloys:		
All forms	3·0	0·3
Copper Alloys	1·0	0·7
Miscellaneous Materials:		
All forms	12·0	1·2
	100·0	100·0

TABLE XIV.—*Cost and Weight Analysis of Steel and Titanium-Alloy Gas-Turbine Parts.*

Item.	Material and Approximate Weight of Finished Part in Steel and in Titanium Alloy, in Lb.		Approximate Cost of Weight Saving Per Lb.
Compressor rotor disc	Steel AMS 6342	25·0 lb.	21*l.*
	Titanium alloy	14·0 lb.	
Compressor stator blade	Steel AMS 5613	0·06 lb.	62*l.*
	Titanium alloy	0·04 lb.	
Turbine support	Steel AMS 6322	3·0 lb.	69*l.*
	Titanium alloy	2·0 lb.	
Compressor rotor blade	Steel AMS 5613	0·10 lb.	84*l.*
	Titanium alloy	0·06 lb.	

TABLE XV.—*Materials Employed in Jet-Engine Construction.*

Material.	Weight as a Percentage of the Total Engine Weight.
Magnesium alloy ..	3·0
Nimonic	10·0
Steel	87·0
	100·0

Design might be effectively improved, while fabrication technique would, by virtue of increased experience and possibly by the use of modified methods, almost certainly become less costly.

To get closer to grips with the gas turbine on the lines which have already been employed with regard to the airframe, the materials employed in a contemporary jet engine of about 9,000 lb. static thrust, are set out in Table XV. The considerable amount of steel in such a jet engine, in contradistinction to the rather limited amount which has been shown in Table XIII to be used in equally contemporary airframes, at once shows how much greater are the possibilities of employing titanium alloys in the former than in the latter.

As has been earlier pointed out, in the airframe the saving in weight due to the use of titanium or titanium alloys is that arising directly from the replacement of a part made in some material by another made in titanium. There is just one exception to this dictum—the case of moving surfaces which have to be mass-balanced and therefore, in addition to the possible direct saving, there is the consequential saving in balance weight.

In the gas turbine, there are a number of parts, enumerated later, which experiment may well show can advantageously be made of titanium alloy. With many of these the saving in weight which will arise is due merely to the titanium part being lighter than the one it replaces. On the other hand, there are cases where one or more additional advantages may be gained. With rotating parts, loads being proportional to density, the use of titanium alloy may well allow of a weight saving greater than that arising from the titanium part being lighter than that which it replaces. A further advantage which will, of course, arise, if the weight of the rotating masses is reduced, is that the polar moment of inertia, and as a consequence gyroscopic couples, will be decreased. Finally, in military aircraft, in which manœuvrability is important, the reduction in lag in speeding up or slowing down the turbine revolutions would be valued.

The use of titanium alloys in aircraft gas turbines is, naturally enough, receiving the most active attention from all makers of such power plants. At present, it is impossible to say with certainty where the existing titanium alloys can be employed, but since, up to a temperature of 400 deg. C. their specific strength is superior to that of alloy steel, it would seem that the most likely field of application will be in the warm rather than in the hot parts of the engine. Those parts which will, it is expected, in the not very distant future, be made of the new material are listed below.

Vanes and stiffeners for anti-icing equipment of the air inlet; rotor blades, rotor spacers, stator blades, discs, and casing of air compressor; outer casing of combustion chambers; bearing housings, levers, tubes for fuel, lubricating oil, etc.

In the airframe, the saving in weight which might be realised in the near future by the use of titanium and/or its alloys is small, if expressed as a percentage of the aeroplane's basic equipped weight; it is nevertheless significant if given in pounds of increased pay-load. With the gas-turbine engine, on the other hand, it is considerable even on a percentage basis. Admittedly there is no agreed figure as between the different British makers of these engines, but three companies have been good enough to give the author what they regard as a possible saving—their estimates, on the basis of "titanising" power plants now in production, are 8, 13 and 20 per cent. Assuming the mid figure to be realisable, then the reduction in weight on the four jet engines used in aircraft "A" of Table XIII would be 1,248 lb. in all, or 1·8 per cent. of its basic-equipped weight. It may well be that the engineer without aeronautical experience will regard this saving as trifling; if so, he should correct this impression by looking at Table X, when he will realise how considerable would be the increase in gross revenue which could arise from such an addition of disposable load.

Conclusion.—In conclusion it should be pointed out that the study which has been made, has been carried out on the assumption that titanium and its alloys might be employed for the replacement of a number of airframe and engine parts of existing aircraft. It seems not unlikely that, by such "titanising," the disposable load of a machine at present having a basic-equipped weight of 70,000 lb.

could be increased by about 1,550 lb. The writer is, however, indebted to E. T. Jones, Principal Director of Scientific Research (Air), Ministry of Supply, for pointing out that there is another way in which this problem can be regarded. If an aircraft of the type already considered were being designed *de novo* to have a certain disposable load, then, by the use of titanium on the lines previously indicated, its basic-equipped weight should be less than would be the case were conventional materials employed. In other words, a slightly smaller aircraft with certain ancillary advantages would give the required disposable load.

Whether in fact such savings in weight will be obtained depends in part on the engineer, but also on the metallurgist. The former, by the exercise of his skill, can undoubtedly exploit the mechanical properties of titanium and its alloys, but in some respects the metallurgist has yet to tell him of them. Present knowledge with regard to their notch characteristics under static, impact and cyclic stresses is wholly inadequate. When in massive form, the variation of their mechanical properties with direction is largely unknown. Means of obviating pick-up of the metal and its alloys on themselves and on other metals have yet to be found. If, however, on these points reasonably satisfactory information is forthcoming, then the author believes he would be able to give an affirmative answer to the question contained in the title of this paper—even at its present price, titanium and its alloys will have applications in chemical and aeronautical engineering and, as the price falls, so the ambit of its use will surely widen.

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LONG-RANGE PHOTO-ELECTRIC PROTECTIVE SYSTEM.

THE range of the photo-electric systems now extensively used for burglar alarms, machine-tool guards and automatic devices has hitherto been limited by the distance over which a ray of light can be effectively projected. This range has now been extended to over 1,000 yards when using white light, or to half that distance when infra-red radiation is employed, by equipment introduced by the General Electric Company, Limited, Kingsway, London, W.C.2. This equipment enables the boundaries of factories, camps and aerodromes to be effectively protected and is, in fact, now being installed at a site having a perimeter of 12 miles. In this case, infra-red radiation is being used because white light would be visible at night.

The apparatus consists of a lamp the radiation from which is interrupted at high speed. When this radiation strikes the associated photo-electric cell it therefore produces an intermittent signal the frequency of which corresponds to the rate of interruption. This signal is then amplified in stages and rectified. The separate unit containing the last stages of amplification and the rectifier also houses the high- and low-voltage supplies for the photo-electric cell and the valves. After rectification, the signal is passed to a relay which operates when the ray is broken so that various protective devices are actuated. Telescopic sights and precise methods of adjustment are provided for aligning the projector and receivers to ensure that the radiation falls accurately on the photo-electric cell.

LONDON DOCKS.

THE London docks began to come into being as a modern system about a century and a half ago, when a company of West India merchants promoted the construction of the West India Docks during the period 1799 to 1802. Maritime trade had been conducted on the river Thames and in the Port of London for many centuries before that date and a number of small dry docks (which have now long since been superseded) had also been built along the banks of the river, but slowly it came to be recognised that much greater convenience would be attained, and the ships would be much safer, lying afloat in totally-enclosed wet docks. The evolution of London docks, and the manner in which their engineering features have changed in accordance with the circumstances of the times, was traced by Mr. W. P. Shepherd-Barron, M.C., T.D., when he delivered his presidential address to the Institution of Civil Engineers on Tuesday, November 3. Mr. Shepherd-Barron has just retired from the post of chief engineer of the Port of London Authority, to which he was appointed in 1938, and, during the course of his address, he pointed out that several of his predecessors as President of the Institution had been responsible for much of the construction and equipment of the docks.

Before dealing with the history of the construction of the five principal groups of docks within the system, Mr. Shepherd-Barron mentioned that it had fortunately proved possible to build most of the dock walls, lock entrances and other foundations required on the Thames-ballast stratum which extends over practically the whole dock area. This material in the undisturbed state is very dense, having a weight in air of about 116 lb. per cubic foot and an angle of internal friction of up to about 42 deg. It is very well graded and forms a splendid natural aggregate for mass concrete, for which it has been used in dock construction. As a foundation material it has proved itself excellent; indeed, one of the few major mishaps to occur during construction concerned the south wall of the Import Dock, part of the East India Dock built in 1879, where the foundation had been taken down to the London clay below the ballast. The wall slipped forward and subsided to some extent and subsequently had to be repaired and stabilised with piling and mass-concrete work along the toe. The fear of losing water from the impounded docks through the pervious ballast apparently influenced the designs of several of the early engineers, but the removal of the ballast and the substitution of puddled clay sometimes proved to be a remedy far worse than the disease. For example, in the construction of the Victoria Dock in the 1850's the whole of the gravel was taken out and puddled clay, 2 ft. thick, substituted in the floors of the entrance lock, the dock and the basin. In this case, the ground water had been kept low by continuous pumping, but when this ceased the water rose, the clay floor lifted and softened, and the walls then subsided, simultaneously moving forward to some extent. The walls had to be rebuilt and the clay puddle was replaced by a lime-concrete invert.

Of the docks built prior to the formation of the Port of London Authority, Mr. Shepherd-Barron suggested that the Royal Albert Dock, constructed between 1874 and 1880 at a cost of 2,200,000*l.*, was probably the most useful and most valuable. It consisted of a dock with straight quays on each side, as distinct from the jetty system of its neighbours. Although opinions differed somewhat on the merits of the two systems of dock layout, the long straight quay had proved its value and flexibility in London and had been adopted for most later works; the jetty system which was not so flexible and was more costly, had been superseded or had, to a large extent, become obsolescent.

All the docks, with the exception of King George V Dock, originated as the properties of various dock companies which, from time to time, were amalgamated and finally taken over in 1909 by the Port of London Authority, as constituted by Act of Parliament. From the beginning, the story has been one of continuous expansion, the earlier docks being built as near to the City as was possible but, as these ceased to be adequate for the shipping, both in respect of actual size as well as of capacity, so additional docks had to be constructed first on one side and then on the other side of the river and farther downstream. In and about 1800, approximately 3,600 ships, with a tonnage of 620,000, entered the river from abroad, together with some 12,000 coastwise vessels with a tonnage of 1,200,000. The largest vessels then using the port were the East Indiamen of 1,550 tons burthen, 199 ft. long and 43½ ft. beam, but they were exceptional and the majority of vessels were of 300 to 400 tons burthen. Until about 1838, ships tended to decrease in size, but in that year the transatlantic wooden paddle-steamer, the British Queen, of 2,016 tons, 234 ft. long and 37½ ft. beam, was put into service. In 1853, the P. and O. Company launched their iron screw-driven steamer, the Himalaya, a vessel of 3,437 tons, 340 ft. long and 44½ ft. beam. Throughout the history of the docks, however, the entrances have always been, except for the very largest of the North Atlantic passenger liners, not only adequate for the largest ships trading to London but, at the time of their construction have provided considerable margin for manœuvring. The Upper Entrance at Tilbury, although built in 1928, still provides a good margin, particularly in respect of length, over the largest present-day vessels using the Port.

An analysis of shipping using the Royal Docks and the West India Docks, made a few years ago, showed that the number of vessels of the largest sizes is very small in comparison with the total and that a second entrance of more moderate dimensions than the largest is a very valuable asset for a dock system, since it enables more shipping to be docked on a tide and also conserves the impounded water. For instance, it was found that, from consideration of size alone, the smaller entrance of the Royal Albert Dock could have been used by two-thirds of the total number of ships entering the Royal group and a somewhat similar proportion could have been locked through the smaller entrance to the West India Dock. It is seldom, if ever, economically possible to justify the provision of two entrances of the largest size for a dock system, Mr. Shepherd-Barron said, but on the other hand, it was of the utmost importance that the dimensions of such entrances should be determined from a careful and generous estimate of the sizes of the largest classes of ships that would be built in the future for the trade of the dock. Once built, dock structures could seldom be altered, except at great expense, and the additional cost of providing a good margin was relatively small. History had shown that, without exception, planning in this way had been fully justified. The cost of ships and the value of their cargoes were now so great that the capital cost of adequate port works, though heavy, was not unduly large in comparison and could be fully justified in the national interest by the economies effected by the larger ships.

An important matter in the determination of the dimensions of entrances was the relationship of beam to length of ships, and this figure had altered considerably during the past 50 years. Existing port works, both at home and abroad, had often imposed limitations on the increase in size of ships, especially of length, by reason of the locks and berths available, and on draught, by reason of the depth of channels which would be difficult and costly to deepen. The only freedom left available to the shipbuilder, therefore, was the beam of the ship, and this could be related to the length by the simple formula, beam $= \frac{\text{length}}{10} + \text{C}$. In 1900, the value of C was of the order of 7, but, at present, it was as high as 19, and Mr. Shepherd-Barron predicted that it might approach 24 in the future.

Since 1910, when the Port of London Authority had been responsible for the improvement and extension of the docks, these considerations had been kept well to the fore by successive chief engineers, so that the mistake of building entrance locks too short should not be made.

ELECTRIC HOT-GALVANISING BATHS.

FIG. 1. 180-KW BATH IN OPERATING POSITION.

FIG. 2. 180-KW BATH FURNACES REMOVED FROM KETTLE.

ELECTRIC HOT-GALVANISING BATH.

AN electrically-heated hot-galvanising bath possessing a number of attractive features has recently been placed on the market by Major Electric Furnaces Pty., Ltd., Melbourne, Australia. It consists essentially of a kettle containing the molten zinc and, arranged around it, the furnace, sometimes, divided into two horseshoe-shaped halves. The kettle rests upon an independent hearth while the two halves of the furnace are carried on wheels so that they may be parted and moved away from the kettle by means of a ratchet lever operated by one man. A galvanising bath of this type is shown in Figs. 1 and 2, on this page; in Fig. 1, the bath is shown in the normal operating position, and in Fig. 2 the two halves of the furnace have been moved away from the kettle, thus permitting easy access to the furnace chamber and kettle exterior for inspection or adjustment. This, it is stated, can be achieved even when the kettle and furnace are at the working temperature, as the operator stands in an updraught of cool air. The bath shown in Figs. 1 and 2 has been installed in the maintenance works of the State Electricity Commission at Melbourne. The internal dimensions of the kettle are 15 ft. by 3 ft. wide by 4 ft. high; the rating of the furnace is 180 kW and the bath is suitable for the galvanising of 1 ton of articles per hour.

A larger bath, now in operation at the works of the Hydro-Electric Commission at Hobart, Tasmania, is shown in the closed operating position in Fig. 3, above. The two longitudinal walls, which can be moved away laterally on the wheels seen in the illustration, accommodate the heating elements, these being of the radiant type. The two end walls are not heated and serve simply to block up the two ends of the furnace. The internal dimensions of the kettle are 24 ft. by 2 ft. 6 in. wide by 4 ft. deep, and the bath has a maximum throughput of 2 tons of articles for galvanising per hour. The electrical rating is 275 kW and the normal bath temperature is 455 deg. C., temperature control being afforded by an indicating electronic potentiometer recorder. Another controller is provided for the limitation of the temperature in the furnace chamber to 575 deg. C., and a third controller protects the bath against the accidental overrunning of the temperature, switching off the heating permanently and operating an alarm signal if the temperature goes beyond 465 deg. C. All the thermocouples employed are specially developed for this type of galvanising bath in that their sheaths do not protrude into the working space of the kettle and thus do not foul dipped articles.

A leakage safety device around the kettle, operated by the first sign of a leak, stops the heating and operates an alarm signal. In such a case, the operator after opening out the furnace and exposing the kettle, which, it is stated, takes three minutes, can easily locate the leak and stop it temporarily. For the non-working hours during the night and at week-ends, the working bath temperature of 455 deg. C. is reduced automatically by an electric time-switch device to a control temperature of 425 deg. C. The full heating energy for the restoration of the galvanising temperature is switched on again automatically before the men arrive to commence work, so that no time is lost waiting for the bath to reach the requisite temperature. The consumption of electrical energy, taking into account heat losses for non-operational hours and week-ends, and working for one shift of eight hours in a five-day week, for an output of one ton of galvanised goods per hour, is given as 353 kWh per ton, and, for an output of two tons of goods an hour, 214 kWh per ton.

Among other advantages claimed for the bath is the high quality of the output owing to the close temperature control and the positive settlement of the dross. Moreover, dross formation is at a minimum and there is a corresponding saving of the zinc by the prevention of overheating and the lowering of the temperature during the non-operating hours. Conditions of working in the galvanising shop are improved as the operators are not exposed to undue heat from the furnace or to noxious gases or fumes from the fuel used. Another advantage is that owing to the moderation and uniformity of the heat impact on to the walls of the kettle, there are no hot spots and the life of the kettle is thereby prolonged. We are indebted to Mr. B. Allert, managing director of Major Electric Furnaces Pty., Limited, for the information upon which this article is based.

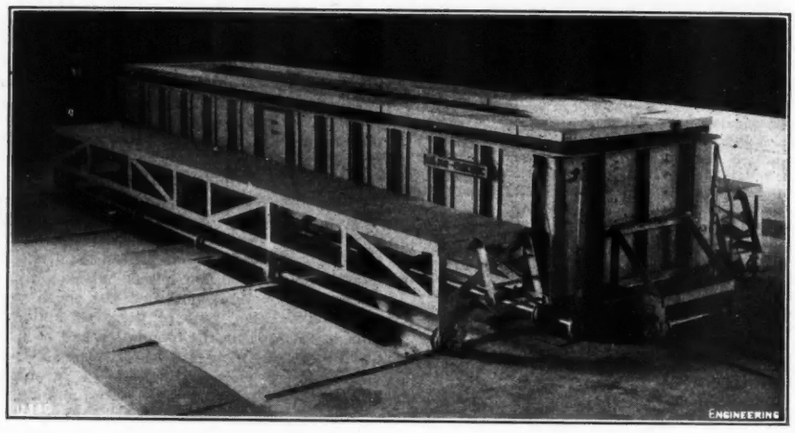

FIG. 3. 275-KW BATH IN OPERATING POSITION.

REGIONAL PLANNING AND DEVELOPMENT.—A meeting convened by the School of Planning and Research for Regional Development, and other organisations, was held at the Imperial Institute, London, recently. It was resolved that there was a "need for a more thorough investigation into the needs and problems of comprehensive development." Consequently, a committee has been appointed to investigate the possibility of a Centre for Regional Planning and Development in London; to encourage the formation of a Regional Planning Association; and to arrange for a conference. Inquiries should be addressed to Mr. N. J. Hart, 23, Heathfield-park, London, N.W.2.

BRITISH GEARS INSTALLED IN AMERICAN RIVER-BOAT.—Oil-operated reverse-reduction gears manufactured by Modern Wheel Drive, Limited, Chesham, Bucks., have recently been installed in the new American twin-screw river-boat Southern, which is driven by two Diesel engines, each rated at 1,400 h.p. at 600 r.p.m. and made by the National Supply Company, Springfield, U.S.A. This type of oil-operated gear has previously been referred to and described in these columns (vol. 174, page 250 (1952) and vol. 172, page 294 (1951)), and their principle—using idling gear-wheels and oil-operated clutches—is well known, but this appears to be the first occasion on which such a transmission has been coupled to American-built engines and installed in an American-owned vessel. The Southern will ply between Pittsburg and New Orleans on the Mississippi, and is designed to push a string of up to 24 barges arranged four abreast, and totalling 20,000 tons.

WELDING RESEARCH IN BRITISH MERCHANT SHIPBUILDING.*

By R. B. Shepheard, C.B.E., B.Sc., M.Inst.N.A.

The use of welding in the building of all classes of merchant ships has developed steadily in Great Britain, though the change from riveting has been less abrupt than in the United States, due to compelling influences during the late war. Widespread and extensive modifications in shipyard layout and equipment have been effected in recent years and afford ample proof of British confidence in the progress made possible by welded design in producing ships of improved performance and efficiency. The rapidity of the welding revolution in world shipbuilding has brought problems in its train, and defects have been disclosed in certain welded ships, especially among those built in the war years; but these deficiencies must be viewed in proper relation to the massive records of satisfactory service given by very large numbers of welded ships. As a result of extensive research and study, and constant vigilance throughout the building processes, the modern welded ship represents a great advance over her older sister, and has been released from the influence of riveted tradition. The present lecture attempts to outline some aspects of welding research affecting shipbuilding in Great Britain during recent years.

The vital importance of adequate notch toughness at service temperatures in mild steel for welded shipbuilding was brought to light by the investigation of failures in certain welded hulls built during the war in the United States. No satisfactory explanation of all the features characteristic of these fractures was found until the importance of notch brittleness in mild steel was realised. Shipbuilders and classification societies, thus confronted with a most complex problem calling for urgent remedial action, enlisted the co-operation of steelmakers and metallurgists, and research was intensified in many directions. Much progress has been made, and amendments to material specifications introduced which have proved their effectiveness; yet there remains much to learn and, with the unremitting demands for heavier rolled material, it is imperative to continue research as a "top priority."

A conference was called in Cambridge in October, 1945, by the British Iron and Steel Research Association,† in which attention was directed first to the chemical composition of the material which had failed, and then to the structure of the steel. The B.I.S.R.A. set up a committee to survey the notch ductility in British-made semi-killed ship plates, and a wider investigation has been completed since on plates from five manufacturers. Triplicate Charpy V-notch impact tests at 0 deg. C. were made on about 700 plates, and the general level of notch ductility for thicknesses from ½ in. to 1¼ in. from each works has been assessed by statistical analysis. This confirmed the known trend for notch ductility to decrease with increase in plate thickness, but disclosed differences between plates of equal thickness made by different manufacturers, the reasons for which are now being sought by studying the conditions of manufacture. A study is also being made of the effects of welding practices, and of the susceptibility of mild steels to strain-ageing.

The relation between laboratory tests and service failures has presented difficulties from the early stages. Two types of test, now being used in the United Kingdom to simulate service conditions and to obtain fundamental information on the initiation and propagation of fractures, both use a full plate thickness—an impossibility in standard impact testing. The Tipper notch tensile-test bar, for determining transition temperatures and relating fracture appearance to ductility, as measured by reduction in thickness, was the first developed in the United Kingdom which reproduced the characteristics of brittle fracture found in welded ships. It has provided good correlation with service casualties, but it is desirable that the width of the test bar should not be less than 2½ times the plate thickness to obtain a sharp transition in the fracture appearance at a given temperature. In the Robertson test, a crack is initiated by impact; either a constant transverse stress is applied to a plate in which there is a temperature gradient or the material is maintained at a constant temperature. Correlation between impact tests, Tipper notch tensile tests and Robertson tests is fairly satisfactory in assessing the temperature at which the change in properties occurs, though numerical agreement is impracticable. The effect of dimensions in testing also renders comparison difficult. The propagating fracture appears to have a typical and constant form, when once established. The interpretation of fracture surface markings has received attention recently from G. M. Boyd.*

The Admiralty Ship Welding Committee have given much attention to the choice of the most suitable test and criterion for assessing notch toughness and recommend, as a single standard test to be used for quality control, the Charpy V-notch impact test; this proposal is in alignment with the practice of the United States Bureau of Standards in their casualty investigations and has been endorsed by the International Institute of Welding. It has been found, however, that the methods by which the V notch is machined can affect the impact values, and, therefore, a closer specification of the conditions for impact testing is being considered. A great step forward would be achieved if an internationally-accepted form of test were agreed. More fundamental researches, also in hand, include work on pure iron and pure-iron alloys—which has shown that, the lower the content of certain elements, the more significant do small amounts become, particularly in the presence of each other; and various studies of fracture stresses in iron and other metal crystals.

The Rules of Lloyd's Register of Shipping were amended in 1949 to require, for ship-quality plate over ½ in. thick, a manganese content not less than 2½ times the carbon content; a provision similar in effect to the Class B specification of the American Bureau of Shipping. For main structural parts exceeding 1 in. in thickness in welded construction, Lloyd's Register also requires that the properties and processes of manufacture of the steel are to be specially approved for the purpose, whereas the American Bureau's Class C requirements lay down no detailed specification for the heavy material. Steelmakers in any country are invited to submit for approval a type of steel which they can readily and consistently produce and which, in their opinion, has adequate notch toughness in thicknesses greater than 1 in. They are required to furnish full details of the proposed process of manufacture, including de-oxidation and rolling practice, limits of composition, and details of any heat-treatment. The steels approved now number 40, from 11 different countries. The system permits initiative and encourages development suitable to individual manufacturing conditions without imposing a rigid specification. Approval is based on direct assessment of notch toughness, determined by physical tests over a range of temperatures.

There remain outstanding problems in this field still unsolved. Among these are the determination of a suitable agreed criterion for the measurement of notch toughness, which must be correlated with service requirements for ships' structures; and a more thorough understanding of the metallurgical effects controlling notch toughness, particularly its reduction with increased thickness and for steels of acceptable weldability.

How do we now regard locked-up stresses? In 1948, a study was made at Cambridge University of stresses in butt-welded mild-steel plates, especially when welded under severe restraint. It showed that high locked-up stresses, generally reaching the yield point, occurred in the immediate vicinity of the weld, even where no restraint was present; and that the magnitude and distribution of residual stresses could be greatly changed by small departures from established procedures, thus throwing doubt on the general belief that residual and reaction stresses could be controlled if correct welding procedures and sequences were followed. It emerged that cracking was due to lack of ductility in the weld metal on cooling, and that it was necessary, therefore, to follow well-established practices in order to limit the plastic deformation required of the weld metal. It has been shown also that, where no notch is present, high reaction stresses could not themselves produce brittle fracture at temperatures below the transition temperature of the material. More recently, however, spontaneous fracture has been produced in specimens in which a severe notch was present, associated with high locked-up stresses, the material having been cooled below its transition temperature.

Dr. A. A. Wells, in explanation of this type of fracture, considers that, if a notch is present before the weld metal cools, work-hardening takes place at the bottom of the notch, raising the average residual stresses to the fracture strength of the material and so initiating a brittle fracture which will propagate at steadily diminishing average stresses, depending on the crack length, under the influence of residual stresses alone. It seems, therefore, that residual stresses cannot be ignored in material which is notch-brittle. Their potential danger can best be eliminated by ensuring a sufficient degree of notch toughness at service temperatures.

The Admiralty Ship Welding Committee have recently amplified their earlier findings on locked-up stresses in the following terms: (*a*) Regardless of the procedure, sequence of welding, or restraint, every welded structure (unless stress-relieved) contains locked-up stresses which locally reach the yield point of the material; (*b*) continued researches have so far not revealed evidence that these locked-up stresses have adverse effects on the strength or reliability of welded ships' structures, provided that the material, including the weld, is in a notch-tough condition at the prevailing temperature; (*c*) it is important, however, to appreciate that undue restraint during fabrication may lead to cracking during or shortly after welding and, unless such cracks are found and dealt with, they may lead to serious failures in service.

The Committee have undertaken a programme of full-scale tests, to throw light on the relative structural behaviour of welded and riveted ships, in still water and at sea. It is hoped that this work, when finally available for critical study, will be found to have contributed usefully to our knowledge of "the way of a ship in the midst of the sea." Systematic full-scale testing of ships' structural members has been carried out on a specially-designed machine at the Glengarnock works of Colvilles, Limited. Five detailed reports of these investigations have been published, and the results have clearly shown the advantages to be derived from the improved fixity of welded compared with riveted construction. Facilities for testing full-scale structures in Great Britain have been greatly extended recently by the completion of a special frame at the Naval Construction Research Establishment, Rosyth.* It is primarily intended to study the design of warship structures, but will also be available, when defence requirements permit, for investigating merchant shipbuilding and other problems. Fatigue testing, by the resonance vibration method, has been applied in a series of fatigue tests of welded specimens consisting of a steel plate, 10 ft. long and 2 ft. wide, stiffened by two angle sections.

Exhibition Stands Built from Standard Units.—The City Display Organisation, 30, Uxbridge-road, London, W.12, have introduced a set of 12 standard Units, designed by Mr. James Gardner, O.B.E., R.D.I., from which a considerable variety of exhibition stands can be constructed very economically. Almost any size of stand, from 12 ft. square upwards, can be built. The standard units are made in five colour schemes.

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* Adams Lecture to the American Welding Society, delivered at the 34th annual meeting, in Cleveland, Ohio, on October 19, 1953. Abridged.

† See Engineering, vols. 164, 165 and 166 (1947 and 1948).

* "The Propagation of Fractures in Mild Steel Plates." Engineering, vol. 175, pages 65 and 100 (1953).

* Engineering, vol. 176, page 115 (1953).

ANNUALS AND REFERENCE BOOKS.

Tyre and Wheel Standards, Car, Commercial Vehicle, Cycle and Motor Cycle, 1953.

The Technical Department, Society of Motor Manufacturers and Traders, Limited, 148, Piccadilly, London, W.1. [Price 17*s.* 6*d.*]

THE contents of the new 1953 edition of the *Tyre and Wheel Standards* handbook and their arrangement follow the general pattern of previous editions but additional data covering tyre and wheel sizes have been added. This edition, it is stated, is the only authoritative current information on the subject. It was drawn up by the tyre and wheel technical committee of the S.M.M.T., whose members are representatives of leading rubber and wheel manufacturers. The book is divided into three sections: the car section, the commercial vehicle section and the cycle and motor-cycle section. The first five pages of the car section are devoted to tables of recommended inflation pressures. A wheel nomenclature is given, and 12 pages are provided on rim contours. Each size of contour is accompanied by a clearly laid out drawing showing all the essential dimensions. The last two pages of the section deal with valves and the method of using ball tapes for rim measurement. In the section dealing with commercial vehicles the inflation pressures are given for an extremely wide range of vehicles for both home and overseas. Rim contours and dimensions are given and there is information on valve apertures, wheel studs, seating and centres, and divided wheels. The last section covers wheel-rim contours and valves for cycles and motor cycles. At the back of the book there are conversion tables and information on the method of measuring tyres and calculating deflection. Reference is also made to the transmission of brake-drum heat.

Electricity Undertakings of the World, 1953-54.

Edited by STANLEY G. RATTEE. 63rd edition. Benn Brothers, Limited, Bouverie House, 154, Fleet-street, London, E.C.4. [Price 30*s.*, post free.]

THE present edition of this useful publication, which is also known as the *Electrical Journal Red Book*, contains a good deal of additional information regarding both Commonwealth and foreign electricity supply undertakings. For instance, Sarawak, Crete, the Dodecanese Islands, Madagascar, India, Greece, Japan, the United States and Colombia are covered, and the addresses of undertakings overseas as well as of those in this country are given. For the rest, full details are given of the various power stations in this country, together with information relating to the 14 electricity boards, particulars of systems of supply, consumers' voltages, etc. The names of the towns and villages served by each District are set out, as are the addresses of the showroom and service centres. The compilation of the annual, as in past years, was largely the responsibility of the late Mr. S. G. Rattee, to whose memory a fitting tribute is paid.

TRADE PUBLICATIONS.

Diesel Engines.—We have received from Davey, Paxman & Co., Ltd., Colchester, a copy of their publication No. 1354 describing a Diesel unit incorporating one of their R.P.H. Series II engines and designed specially for oil-well drilling. The publication is made particularly interesting by a set of eight coloured sectional "transparencies" of the 12-cylinder version of the engine clearly showing details of its construction.

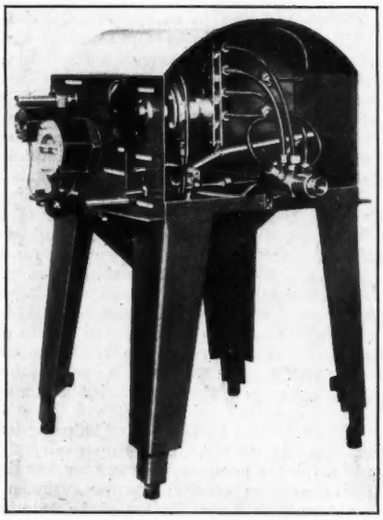
Gearboxes for Commercial Vehicles.—David Brown Corporation (Sales), Ltd., Automobile Gearbox Division, Park Works, Huddersfield, have sent us two illustrated leaflets describing their model 542 and 557 gearboxes for use with commercial vehicles. Both boxes have five speeds and are suitable for forward control; the model 542 is also available with a centrally-fitted gear lever. They are both available with clutch housings for mounting directly on to an engine, and the model 542 is rated for use with vehicles of 5 to 6 tons capacity, while the model 557 is for vehicles of 15 tons capacity.

Electrical Plant for Wool Industry.—The English Electric Co. Ltd., have published an illustrated booklet entitled "The Power Behind the Wool Industries." It contains details of the generating plant, switchgear, transformers, motors and control equipment which the firm have designed for use in the industry. Copies can be obtained from the Publicity Department, Foregate-street, Stafford.

Fireless Steam Locomotives.—A brochure has been received from W. G. Bagnall, Ltd., Stafford, illustrating and describing the fireless steam locomotives which they manufacture. These locomotives carry a heavily-insulated steam reservoir in place of the conventional boiler and firebox and are charged at 250 to 350 lb. per square inch from stationary boiler plant in under 20 minutes; being fireless, they are eminently suitable for shunting purposes in oil refineries and similar plants where there is a fire hazard.

WASTE-OIL FIRING UNIT.

THE illustration below shows the oil-jet and control panel sides of the Kamel waste-oil firing unit, manufactured by Kamel Products, Limited, 21, Leigh-street, Liverpool. As its name implies, the unit is designed to utilise waste oil, and it is therefore especially suitable for use in garages where the disposal of waste oil can be a problem. With the legs fully telescoped as shown in the illustration, the unit stands 2 ft. in height with an overall width and length of 1 ft. 6 in. and 1 ft. 7 in., respectively; the distance of the centre-line of the jet then being 1 ft. 3 in. above floor level, although this distance can be reduced by a further 2 in. by removing the lower half of the telescopic legs. With the legs fully extended, the jet can be raised to a maximum height of 2 ft. 2 in. above floor level. The unit is self-contained and is suitable for oil-firing central-heating boilers rated at between 100,000 and 350,000 B.Th.U., and it is only necessary to open



the fire door of such a boiler, and to place the unit (after adjusting it for height) immediately in front of the opening. Reversion to normal stoking with solid fuel merely requires the lifting away of the unit.

The firing unit consists of a small oil reservoir which is fitted with a thermostatically-controlled immersion heater and which is connected to a supply tank by flexible piping; this supply tank may be any suitable container of approximately 40 gallons capacity. An air coil is immersed in the reservoir and derives its heat from the electrically-heated oil; also fitted are an air-pressure reducing valve, together with a pressure gauge, a high-pressure jet blasting control, and oil supply control valves. The oil is controlled by a needle valve for giving the correct setting, in conjunction with a control lever which incorporates an on/off cock. The unit is provided with a flash plate, back plate and lighting rod and consumes from 1 to 2 gallons of waste-oil an hour, depending on the size of the boiler fired, and is specifically designed to handle waste oil which is not clean and filtered, and in the case of lubricating oil, is of a very much higher flash-point than the 165 deg. F. of normal fuel oils.

SILICONE RUBBER EXHIBITION.—Industrial and other uses for silicone rubber will be shown at an exhibition arranged by Midland Silicones Ltd., 19, Upper Brook-street, London, W.1. Demonstrations will also be given of the properties of this material and of the latest grades. The exhibition will be open from December 2 to 10. Admission will be by invitation, obtainable from the firm.

BLAST-FURNACE SLAG CEMENT PLANT AT CLUANIE DAM: ERRATUM.—On page 557 of our issue of October 30, it was incorrectly stated that the quarry opened by Mitchell Construction Company for their contract at Cluanie Dam has a capacity of 200 tons per day. This should have been 200 tons per hour.

BOOKS RECEIVED.

The Motor Vehicle. By PROFESSORS K. NEWTON and W. STEEDS. Fifth edition. Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 35*s.* net.]

The Rugby Engineering Society. Proceedings. Session 1952-53: Vol. XLIII. The Librarian and Recording Secretary, c/o Publicity Department, The British Thomson-Houston Company, Limited, Rugby. [Price 10*s.* 6*d.*]

Theory and Practice of Structural Design Applied to Reinforced Concrete. By B. ERIKSEN. Concrete Publications, Limited, 14, Dartmouth-street, London, S.W.1. [Price 25*s.*]

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THE MINING MACHINERY OF THE ATLAS DIESEL COMPANY.

THE principal material resources of Sweden are iron ore, timber and water power. The development of the third of these was dealt with in an article published in ENGINEERING last year,* while the second, although it is an important factor in the nation's prosperity, presents only simple problems from the mechanical point of view. On the other hand, the mining of iron ore and its subsequent processing into steel of different grades have led to the design and manufacture of a great deal of interesting equipment; and this in turn has brought about a number of economic advantages. Some indication of the progress made in these directions is given in this article.

The main ore deposits of Sweden are to be found in the centre of the country, where the yield of the Bergslagen in 1951 was some 4 million tons with both high and low phosphorus contents. About one-quarter of this total yield was processed in Sweden, a proportion into high-quality steel, while the rest was exported. In Lapland, there are vast deposits of magnetic ores at Kiruna and Gällivare, which contain from 60 to 71 per cent. of iron and 1 to 2 per cent. of phosphorus. In 1951 the yield from these fields was about 12 million tons, almost all of which was exported without preliminary processing.

Two main methods of producing steel from these ores are employed, one of which, based on charcoal iron, concentrates on the manufacture of high-quality grades, both for home consumption and export, while the other, based partly on coke iron, but mostly upon scrap, is used for the production of structural steel, rails and wire rods. In 1951 the high-quality steels accounted for 27 per cent. of the total output by volume, but their manufacture has recently been threatened by a shortage of charcoal. The steel-makers are therefore expanding their facilities for the production of sponge iron, the output of which is expected to increase considerably from the present figure of 40,000 tons per annum when works now in course of erection are opened. For the production of steel, both open-hearth and electric-arc furnaces are used, each accounting for about 34 per cent. of the ingots manufactured, while 15 per cent., including the steels of special quality which are required for such purposes as ball-bearing manufacture, is made by the acid open-hearth process. High-speed tool steels and stainless steels are mainly smelted in induction furnaces.

High-quality tool metal has been made in Sweden for over 800 years and 200 years ago 40 per cent. of the world's iron output was produced in that country. Nevertheless, it was not until about the middle of last century, when the railway system was inaugurated, that development began on a really large scale. This development naturally led to the formation of manufacturing firms, among which was the Aktiebolaget Atlas, which was founded at Södertälje in 1873 for the production of all kinds of materials used in the building and operation of railways. As far as locomotives and carriages were concerned, this work was carried out in co-operation with the British firm of Beyer, Peacock and Company. In 1891 the Atlas factory was moved to Stockholm and the manufacture of machine tools, bridges and other structures was added to its original activities. This move corresponded with a period of trade depression, the result of which was that the company was reconstructed as the Nya Aktiebolaget Atlas. The setback was, however, temporary and two years later the production of caulking hammers was started, a step which may be said to mark the genesis of one of the present organisation's principal activities. Compressors of both Swedish and German design for supplying the necessary air for these tools were added to the range of manufactures in 1905, so that the firm was then able to provide equipment for one complete branch of iron-ore mining.

In the meantime, another interesting development had taken place in the shape of an agreement with Dr. Rudolf Diesel to manufacture his engines under licence, a company known as Aktiebolaget Diesel Motoren being formed for this purpose. The first of these engines was completed in 1899. Since then, more than 600 ships have been equipped and more than 7,200 stationary units with outputs ranging from 50 to 5,000 h.p. have been supplied. The two companies—Nya Aktiebolaget Atlas and Aktiebolaget Diesel Motoren—were amalgamated in 1917 as Aktiebolaget Atlas Diesel. In 1948, owing to the increasing production of air compressors of both the stationary and mobile types as well as of pneumatic tools of all kinds, it was found desirable to abandon the manufacture of Diesel engines, which was accordingly transferred to Nydqvist and Holm A/B., of Trollhättan. In addition, the widespread acceptance of the Swedish method of tunnelling, largely evolved by Atlas, meant that extra factory space was needed for the production of rock drills and auxiliary equipment. Other manufactures are fuel-injection pumps for Diesel engines and many types of air-operated rotary tools, such as drills and grinders, paint-spray guns and their accessories, pneumatic loaders, air hoists and winches.

These activities of Atlas Diesel are carried out in a number of factories, the largest of which is at Sickla on the outskirts of Stockholm. A view of the newer parts of this works, which now covers a floor area of 522,000 sq. ft. in addition to extensive office buildings, and where there is employment for some 2,300 workers, is given in Fig. 1. The main building accommodates a large shop consisting of four bays in which compressors are produced. Adjacent to this are the grinding department and automatic and semi-automatic lathe shops and separate beds for the assembly and testing of stationary and portable compressors. Other buildings are devoted to heat treatment and forging and pickling processes, and there are extensive stores for both raw materials and finished products. The production of rock drills and the carrying out of general turning, milling, drilling and tool-sharpening operations are conducted in shops above the grinding department, and experimental laboratory and research departments are accommodated in separate buildings. Fig. 2, Plate XXXIV, is a view of part of the shop in which stationary compressors are assembled, while Fig. 4, on the same Plate, is an illustration of the shop in which the portable compressors are built up and Fig. 11, on page 643, illustrates the grinding shop. Finally, mention may be made of a test mine, a corner of which is illustrated in Fig. 6, Plate XXXV, in which tests are made on drills—an operation which is facilitated by the rocky sub-soil of Stockholm.

A power supply for the works is obtained from the city of Stockholm electricity system and is transformed to 380 volts for power and 110 volts for lighting purposes in 23 transformers with a total capacity of 8,200 kVA. The aggregate horse-power of the 1,570 electric motors involved for driving the various machines is about 10,000 h.p. and the annual electrical consumption is rather over 13·2 million kilowatt-hours. Water for cooling and domestic purposes is drawn from Lake Langsjön by five electrically-driven pumps. Hot and warm water for heating is obtained from 19 boilers, which also supply low-pressure steam for process purposes.

FIG. 1. VIEW OF PART OF THE SICKLA WORKS, STOCKHOLM.

* See ENGINEERING, vol. 174, page 585 (1952).